SLCP Research Digest

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The SLCP Research Digest is a bi-monthly publication aimed at compiling the top research in fields related to short-lived climate pollutants. While the Digest draws from a wide list of scientific research publications it is not meant to be a fully exhaustive compilation of the relevant published research. Suggestions for published research to be included in future Digests should be emailed to ccac_secretariat@unep.org, *with the subject line 'For SLCP Research Digest' we particularly welcome published research from non-English sources.*

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SHORT-LIVED CLIMATE POLLUTANTS

Counteracting the climate effects of volcanic eruptions using short-lived greenhouse gases

Abstract - A large volcanic eruption might constitute a climate emergency, significantly altering global temperature and precipitation for several years. Major future eruptions will occur, but their size or timing cannot be predicted. We show, for the first time, that it may be possible to counteract these climate effects through deliberate emissions of short-lived greenhouse gases, dampening the abrupt impact of an eruption. We estimate an emission pathway countering a hypothetical eruption 3 times the size of Mount Pinatubo in 1991. We use a global climate model to evaluate global and regional responses to the eruption, with and without counter emissions. We then raise practical, financial, and ethical questions related to such a strategy. Unlike the more commonly discussed geoengineering to mitigate warming from long-lived greenhouse gases, designed emissions to counter temporary cooling would not have the disadvantage of needing to be sustained over long periods. Nevertheless, implementation would still face significant challenges.

BLACK CARBON

Coherent approach for modeling and nowcasting hourly near-road Black Carbon concentrations in Seattle, Washington

Abstract - With a growing awareness of the importance of near-road air pollution and an increasing population of near-road pedestrians, it is imperative to "nowcast" near-road air quality conditions to the general public. This necessitates the building hourly predictive models that are both accurate and easy to use. This study demonstrates an approach to model the hourly near-road Black Carbon (BC) concentrations given on-road traffic information and current meteorological conditions using datasets from two urban sites in Seattle, Washington. The optimal set of prediction variables is determined with a Bayesian Model Averaging (BMA) method and three different model structures are further developed and compared by goodness-of-fit. An innovative approach is proposed to translate wind direction from numerical values to categorical variables with statistical significance. By modeling the autocorrelation within the BC time series using an AR(1) component, the model achieves a satisfactory prediction accuracy. The conditional heteroscedasticity and heavy-tailed distribution of the model residuals are successfully identified and modeled by the General Auto Regressive Conditional Heteroscedasticity (GARCH) model, which provides valuable insights to the interpretation of prediction results. The methodological procedure demonstrated in selecting and fine-tuning the model is computationally efficient and valuable for further implementation onto online platforms for near-road BC nowcasting. A comparison between the two sites also reveals the effectiveness of local freight regulation for mitigating the environmental impacts from a heavy truck fleet.

Black carbon aerosols in urban central China

Abstract - The first ever (to our knowledge), year-round measurements of Black Carbon (BC) aerosols in Hefei, an urban site of central China, from June 2012 to May 2013 are performed. The aim of this

paper is to evaluate the black carbon in Hefei in terms of seasonal, monthly and diurnal variations, including their source identification. The annual mean BC mass concentration MBC is found to be 3.5 2.5 g m 3 in Hefei, while the aerosol optical depth shows a yearly average value of ~0.6. The seasonality of MBC depicts minimum values in the summer, moderate levels in the spring and fall, and maximum in the winter. The monthly average values of MBC vary threefold, ranging from the lowest average value of 2.0 1.0 g m 3 in July to the highest 6.0 2.6 g m 3 during January. Diurnal variations exhibit two BC peaks, corresponding to the morning and evening rush hours. Higher median BC concentrations are observed during haze episodes compared with non-haze periods, although low MBC is sometimes observed for high visibility, which is probably indicative of the aerosol scattering dominating diminished visibility. Based on trajectory analyses, the haze BC pollutions are mostly classified into three types from local areas, long-range transport from the Yangtze Delta, and transport from the North China Plain. The median MBC values for haze groups attributed to biomass burning from MODIS wildfire maps are higher than related groups that are not, which is indicative of the significant enhancement of BC aerosols due to agricultural biomass burning. The study suggests that aerosol absorption contributes more to the observed haze episodes in fall compared to other seasons.

Zhang, X., R. Rao, Y. Huang, M. Mao, M. J. Berg, & W. Sun (2015) *Black carbon aerosols in urban central China*, JOURNAL OF QUANTITATIVE SPECTROSCOPY AND RADIATIVE TRANSFER 150:3-11.

The identification of source regions of black carbon at a receptor site off the eastern coast of China

Abstract - The black carbon (BC) mass concentration and the particle chemical compositions were continually measured at Changdao Island, which is a regional receptor site off the eastern coast of China. This island is in the transport passage of the continental outflow to the Pacific Ocean when the East Asia monsoon prevails in the winter and spring. The campaign period was for March and April 2011, which corresponded to heating and non-heating periods in northern China. The effect of BC emission source regions on BC measured at Changdao Island between the heating and non-heating periods was determined by integrating the total potential source contribution function (TPSCF) model with the new monthly emission inventory in 2010 and the fire counts retrieved from MODIS during the campaign. BC concentrations were determined to be highest for similar times of day for both the heating and non-heating periods: 4.27 g m 3 at 8:00 AM and 3.06 g m 3 at 9:00 AM, respectively. The probable source regions for BC were primarily located in Shandong and Jiangsu provinces (and in other neighboring provinces) for both periods. However, the source regions for the non-heating period extended more to the north and southwest than those of the heating period. TPSCF values were correlated with the emission rates from residential, industry, transportation, and power plants sources in the anthropogenic emission inventory. This correlation provides an indirect and qualitative process to verify the emission inventory. In the heating period, the predominant source was the residential source in the emission inventory, and this source had a significant effect on the BC concentration. The differing peak concentrations between the two periods may be observed because of the increased residential heating during the heating period, which suggested that the measures employed by the government and environmental managers to reduce the emissions of pollutants should be stricter in the identified source regions during the heating period.

Guo, Q., M. Hu, S. Guo, Z. Wu, W. Hu, J. Peng, W. Hu, Y. Wu, B. Yuan, Q. Zhang, & Y. Song (2015) *The identification of source regions of black carbon at a receptor site off the eastern coast of China*, ATMOSPHERIC ENVIRONMENT 100:78-84.

Modelling Black Carbon concentrations in two busy street canyons in Brussels using CANSBC

Abstract - This paper focused on modelling Black Carbon (BC) concentrations in two busy street canyons, the Crown and Belliard Street in Brussels. The used original Operational Street Pollution Model was adapted to BC by eliminating the chemical module and is noted here as CANSBC. Model validations were performed using temporal BC data from the fixed measurement network in Brussels. Subsequently, BC emissions were adjusted so that simulated BC concentrations equalled the observed ones, averaged over the whole period of simulation. Direct validations were performed for the Crown Street, while BC model calculations for the Belliard Street were validated indirectly using the linear

relationship between BC and NOx. Concerning the Crown Street, simulated and observed half-hourly BC concentrations correlated well (r = 0.74) for the period from July 1st, 2011 till June 30th, 2013. In particular, CANSBC performed very well to simulate the monthly and diurnal evolutions of averaged BC concentrations, as well as the difference between weekdays and weekends. This means that the model correctly handled the meteorological conditions as well as the variation in traffic emissions. Considering dispersion, it should however be noted that BC concentrations are better simulated under stable than under unstable conditions. Even if the correlation on half-hourly NOx concentrations was slightly lower (r = 0.60) than the one of BC, indirect validations of CANSBC for the Belliard Street yielded comparable results and conclusions as described above for the Crown Street. Based on our results, it can be stated that CANSBC is suitable to accurately simulate BC concentrations in the street canyons of Brussels, under the following conditions: (i) accurate vehicle counting data is available to correctly estimate traffic emissions, and (ii) vehicle speeds are measured in order to improve emission estimates and to take into account the impact of the turbulence generated by moving vehicles on the local dispersion of BC.

Brasseur, O., P. Declerck, B. Heene, & P. Vanderstraeten (2015) Modelling Black Carbon concentrations in two busy street canyons in Brussels using CANSBC, ATMOSPHERIC ENVIRONMENT 101:72-81.

Light attenuation cross-section of black carbon in an urban atmosphere in northern China

Abstract - Fine particulate matter (PM2.5) samples were collected over two years in Xi'an, China to investigate the relationships between the aerosol composition and the light absorption efficiency of black carbon (BC). Real-time light attenuation of BC at 880 nm was measured with an aethalometer. The mass concentrations and elemental carbon (EC) contents of PM2.5 were obtained, and light attenuation cross-sections (ATN) of PM2.5 BC were derived. The mass of EC contributed ~5% to PM2.5 on average. BC ATN exhibited pronounced seasonal variability with values averaging 18.6, 24.2, 16.4, and 26.0 m2/g for the spring, summer, autumn, and winter, respectively, while averaging 23.0 m2/g overall. ATN varied inversely with the ratios of EC/PM2.5, EC/[SO42], and EC/[NO3]. This study of the variability in ATN illustrates the complexity of the interactions among the aerosol constituents in northern China and documents certain effects of the high EC, dust, sulfate and nitrate loadings on light attenuation.

Cao, J., C. Zhu, K. Ho, Y. Han, Z. Shen, C. Zhan, & J. Zhang (2015) Light attenuation cross-section of black carbon in an urban atmosphere in northern China, PARTICUOLOGY 18:89-95.

An empirical correction factor for filter-based photo-absorption black carbon measurements

Abstract - Filter-based BC measurement techniques such as the Continuous Soot Monitoring System (COSMOS) are particularly well suited to long-term observations of black carbon (BC) due to their relative robustness and reliability. However, caution is required when determining the threshold transmittance, Trthresh (roughly proportional to the time interval between filter changes), in order to ensure that acceptable measurement accuracy is maintained throughout the sampling period. We present a new, empirically derived transmittance-dependent correction factor used to interpret the response characteristics of filter-based aerosol absorption measurements performed by COSMOS. Simultaneous measurements of ambient BC aerosol mass (MBC) were conducted in Tokyo, Japan, using two identical COSMOS instruments operated with different threshold transmittance, Trthresh, values, of 0.95 and 0.6. The derived values for MBC were consistently underestimated by the COSMOS operating at lower Trthresh, as a function of decreasing filter transmittance. The 1-hour averaged values of MBC were underestimated by around 10%, incorporating measurements across the entire range of filter transmittance (1–0.6), with a maximum underestimation at around 17% immediately preceding filter advancement (i.e. Tr=~0.6). An empirical correction factor was derived from these ambient measurements, and was applied to MBC as a function of filter transmittance, resolving the instruments to within 2%. Further to the transmittance-based correction, the operational performance of COSMOS was tested for two types of quartz fibre filter (PALLFLEX and HEPA). Agreement in derived values of MBC for two COSMOS using the same type of filter was around 2%; however, a comparison of the PALLFLEX and HEPA filters demonstrated a systematic overestimation of MBC derived when using HEPA filters, of around 6–8%. A sensitivity study of a radiative transfer

model indicated that this enhanced absorption was primarily a result of the increased thickness of the HEPA filter.

Irwin, M., Y. Kondo, & N. Moteki (2015) An empirical correction factor for filter-based photo-absorption black carbon measurements, JOURNAL OF AEROSOL SCIENCE 80:86-97.

The effect of complex black carbon microphysics on the determination of the optical properties of brown carbon

Abstract - Assessment of the impacts of brown carbon (BrC) requires accurate determination of its physical properties, but a model must be invoked to derive these from instrument data. Ambient measurements were made in London at a site influenced by traffic and solid fuel (principally wood) burning, apportioned by single particle soot photometer data and optical properties measured using multiwavelength photoacoustic spectroscopy. Two models were applied: a commonly used Mie model treating the particles as single-coated spheres and a Rayleigh-Debye-Gans approximation treating them as aggregates of smaller-coated monomers. The derived solid fuel BrC parameters at 405 nm were found to be highly sensitive to the model treatment, with a mass absorption cross section ranging from 0.47 to 1.81 m2/g and imaginary refractive index from 0.013 to 0.062. This demonstrates that a detailed knowledge of particle morphology must be obtained and invoked to accurately parameterize BrC properties based on aerosol phase measurements.

Liu1, D., J. W. Taylor, D. E. Young, M. J. Flynn, H. Coe, & J. D. Allan (2015) The effect of complex black carbon microphysics on the determination of the optical properties of brown carbon, GEOPHYSICAL RESEARCH LETTERS (Early View).

In-situ observations of black carbon in snow and the corresponding spectral surface albedo reduction

Abstract - Black carbon (BC) particles emitted from incomplete combustion of fossil fuel and biomass, and deposited on snow and ice, darken the surface and reduce the surface albedo. Even small initial surface albedo reductions may have larger adjusted effects due to snow morphology changes, and changes in the sublimation- and snow melt rate. Most of the literature on the effect of BC on snow surface albedo is based on numerical models, and few in situ field measurements exist to confirm this reduction. Here we present an extensive set of concurrent in situ measurements of spectral surface albedo, BC concentrations in the upper 5-cm of the snow pack, snow physical parameters (grain size and depth), and incident solar flux characteristics from the Arctic. From this dataset (with median BC concentrations ranging from 5 to 137 ng BC per gram of snow) we are able to separate the BC signature on the snow albedo from the natural snow variability. Our measurements show a significant correlation between BC in snow and spectral surface albedo. Based on these measurements, parameterizations are provided, relating the snow albedo, as a function of wavelength, to the equivalent BC content in the snow pack. The term equivalent BC used here is the elemental carbon concentration inferred from the thermo-optical method adjusted for the fraction of non BC constituents absorbing sunlight in the snow. The first parameterization is a simple equation which efficiently describes the snow albedo reduction due to the equivalent BC without including details on the snow or BC microphysics. This can be used in models when a simplified description is needed. A second parameterization, including snow grain size information, shows enhanced correspondence with the measurements. The extracted parameterizations are valid for wavelength bands 400–900 nm, constrained for BC concentrations between 1 and 400 ng g 1, and for an optically thick snowpack. The parameterizations are purely empirical, and particular focus was on the uncertainties associated with the measurements, and how these uncertainties propagate in the parameterizations. Integrated, the first parameterization (based only on the equivalent BC) gives a broadband (400–900 nm) snow albedo reduction of 0.004 due to 10 ng equivalent BC per gram of snow, while the effect is almost five times larger for BC concentrations one order of magnitude higher. The study shows that the reconstructed albedo from the second parameterization (including information on the snow grain size) corresponds better to the radiative transfer model Snow, Ice, and Aerosol Radiation (SNICAR) albedo than the reconstructed albedo from the first parameterization (excluding grain size information).

Pedersen, C. A., J.-C. Gallet, J. Ström, S. Gerland, S. R. Hudson, S. Forsström, E. Isaksson, & T. K. Berntsen (2015) In-situ observations of black carbon in snow and the corresponding spectral surface albedo reduction, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Accepted Article).

Black carbon radiative forcing over the Indian Arctic station, Himadri during the Arctic Summer of 2012

Abstract - The warming of Arctic region has recently gained worldwide attention due to its projected impacts on global climate system. The effect of anthropogenic black carbon (BC) aerosol on snow is of enduring interest due to its role in aerosol radiative forcing and further consequences for Arctic and global climate change. Using an A ethalometer, measurements of BC aerosols were continuously carried out over the Indian Arctic Station, Himadri during the Arctic Summer (23 July to 19 August) of 2012. Monthly mean BC mass concentration during July and August was found to be 0.093   0.046 and 0.069   0.050 g/m3, respectively. BC mass concentration showed maximum loading during 0800–1600 LT. Transport from distant sources (as observed from air mass back trajectories) apart from some local anthropogenic activities (emissions from shipping and power plant) could be the possible sources for observed BC concentration at Himadri. Using the OPAC and SBDART models, optical properties and aerosol radiative forcing (ARF) in the spectral range 0.2 to 4 m for composite aerosol and without-BC aerosol at the top of the atmosphere, surface and atmosphere were computed. The presence of BC resulted in positive radiative forcing in the atmosphere leading to warming effect (+ 2.1 W/m2) whereas cooling was observed at the top of the atmosphere (0.4 W/m2) and at surface (2.5 W/m2). BC formed about 57% of atmospheric ARF.

Raju, M. P., P. D. Safai, S. M. Sonbawne, & C. V. Naidu (2015) Black carbon radiative forcing over the Indian Arctic station, Himadri during the Arctic Summer of 2012, ATMOSPHERIC RESEARCH 157:29-36.

Technique and theoretical approach for quantifying the hygroscopicity of black-carbon-containing aerosol using a single particle soot photometer

Abstract - A single particle soot photometer (SP2), an instrument that measures the optical size and refractory black carbon (BC) mass content of individual aerosol particles, was modified to include a compact humidification system, described here. This permits quantification of water uptake by BC-containing particles, an important process that can affect their optical properties and lifetime. A Mie and -Köhler theory framework was developed to relate measured humidity-dependent changes in BC aerosol optical size to the hygroscopicity parameter ( ) of the non-BC content in the particles (which is responsible for water uptake by these particles). Laboratory testing of this experimental and theoretical system with both homogeneous non-light-absorbing particles and BC-containing particles was carried out. Agreement between the theoretical predictions and laboratory measurements for the homogenous aerosols validates the experimental methodology. For BC with a 70-nm thick coating of ammonium sulfate, reasonable agreement (equivalent to ~20% in) between measurements and theoretical predictions were observed over a span of RH from 70% to 90%. Two SP2s were configured to sample in parallel, one dry and one humidified, permitting continuous monitoring of water uptake by BC-containing aerosol. Operational refinements in SP2 setup to optimize the optical size measurement of BC-containing aerosol, and the consistency between the two SP2s are presented. This system was flown on the NASA DC8 research aircraft during the 2012 DC3 and 2013 SEAC4RS campaigns, providing engineering data included here that demonstrate the system's performance under challenging sampling conditions. Finally, SP2-scattering lookup tables used in the theoretical portions of this work are provided for reference.

Schwarz, J. P., A. E. Perring, M. Z. Markovic, R. S. Gao, S. Ohata, J. Langridge, D. Law, R. McLaughlin, & D. W. Fahey (2015) Technique and theoretical approach for quantifying the hygroscopicity of black-carbon-containing aerosol using a single particle soot photometer, JOURNAL OF AEROSOL SCIENCE 81:110-126.

Spatial variation of ultrafine particles and black carbon in two cities: Results from a short-term measurement campaign

Abstract - Recently, short-term monitoring campaigns have been carried out to investigate the spatial variation of air pollutants within cities. Typically, such campaigns are based on short-term measurements at relatively large numbers of locations. It is largely unknown how well these studies capture the spatial variation of long term average concentrations. The aim of this study was to evaluate the within-site temporal and between-site spatial variation of the concentration of ultrafine particles (UFPs) and black carbon (BC) in a short-term monitoring campaign. In Amsterdam and Rotterdam (the Netherlands) measurements of number counts of particles larger than 10 nm as a

surrogate for UFP and BC were performed at 80 sites per city. Each site was measured in three different seasons of 2013 (winter, spring, summer). Sites were selected from busy urban streets, urban background, regional background and near highways, waterways and green areas, to obtain sufficient spatial contrast. Continuous measurements were performed for 30 min per site between 9 and 16 h to avoid traffic spikes of the rush hour. Concentrations were simultaneously measured at a reference site to correct for temporal variation. We calculated within- and between-site variance components reflecting temporal and spatial variations. Variance ratios were compared with previous campaigns with longer sampling durations per sample (24 h to 14 days). The within-site variance was 2.17 and 2.44 times higher than the between-site variance for UFP and BC, respectively. In two previous studies based upon longer sampling duration much smaller variance ratios were found (0.31 and 0.09 for UFP and BC). Correction for temporal variation from a reference site was less effective for the short-term monitoring campaign compared to the campaigns with longer duration. Concentrations of BC and UFP were on average 1.6 and 1.5 times higher at urban street compared to urban background sites. No significant differences between the other site types and urban background were found. The high within to between-site concentration variances may result in the loss of precision and low explained variance when average concentrations from short-term campaigns are used to develop land use regression models.

Klompmaker, J. O., D. R. Montagne, K. Meliefste, G. Hoek, & B. Brunekreef (2015) *Spatial variation of ultrafine particles and black carbon in two cities: Results from a short-term measurement campaign*, SCIENCE OF THE TOTAL ENVIRONMENT 508:266-275.

15,000 years of black carbon deposition – A post-glacial fire record from maar lake sediments (Germany)

Abstract - Fires accompanied human development throughout the Holocene, leaving behind black carbon (BC) as residues from incomplete biomass burning. Here we used molecular fire markers, benzene polycarboxylic acids (BPCAs), to reconstruct fire history in two Eifel maar lakes, Germany. We hypothesized to find indications for (i) changes in BC related to ecosystem changes, (ii) an increase in BC influx at the onset of agriculture until modern times, and (iii) a change in BC quality due to technical progress in combustion, e.g., at the beginning of agriculture and at the onset of the Bronze Age. To calculate absolute BC influx into the maar lakes, we multiplied BC contents with sedimentation rates. The BC influx rates were elevated during tundra-like vegetation in the Late Pleistocene (up to 7.7 g BC m 2 a 1), followed by relatively constant 2.5 g BC m 2 a 1 from the Bølling interstadial (>13.7 kilo years before present, ka BP) until the early Atlantic when forest began to develop. Thereafter, BC influx increased with the onset of land use of Neolithic cultures in the region from 7.5 ka BP to rates of 7–9 g BC m 2 a 1. Noteworthy, also the quality of BC changed: higher ratios of five-to six-times carboxylated benzenes (B5CA/B6CA) pointed at colder, arable fires approximately 1000 years after first Neolithic activity from 6 to 4 ka BP (B5CA/B6CA increased from 1.0 to 2.0). From 4 ka BP (Bronze Age) to modern times increasing burning temperatures as indicated by dropping B5CA/B6CA ratios (from 2.0 to 1.0) were related to metallurgy and industrialization. Between 2.5 and 1 ka BP maximum BC influx rates were reached with ca 15 g BC m 2 a 1. With increasing combustion efficiency and a reduction of wild fires during the last centuries, total BC influx decreased, suggesting that fossil fuel combustion contributed less to total BC input into the lake sediments than former vegetation fires.

Lehndorff, E., M. Wolf, T. Litt, A. Brauer, & W. Amelung (2015) *15,000 years of black carbon deposition – A post-glacial fire record from maar lake sediments (Germany)*, QUATERNARY SCIENCE REVIEWS 110:15-22.

Partitioning of Black Carbon between ultrafine and fine particle modes in an urban airport vs. urban background environment

Abstract - In this work, we characterize the Black Carbon (BC) aerosol in an urban airport vs. urban background environment with the objective to evaluate when and how the ultrafine BC dominates the bulk aerosol. Aerosol optical and microphysical properties were measured in a Mediterranean urban area (Rome) at sites impacted by BC sources including fossil fuels (FF), and biomass burning (BB). Experimental BC data were interpreted through measurement-constrained simulations of BC microphysics and optical properties. A "scheme" to separate the ultrafine BC was experimented on

the basis of the relation found between changes in the BC partitioning between Aitken and accumulation mode particles, and relevant changes in particle size distribution and optical properties of the bulk aerosol. This separation scheme, applied to experimental data, proved useful to reveal the impact of airport and road traffic emissions. Findings may have important atmospheric implications. The experimented scheme can help separating different BC sources (FF, BB, "aged" BC) when BC size distributions may be very difficult to obtain (satellite, columnar observations, routine monitoring). Indeed, separating the ultrafine BC from the fine BC may provide significant benefits in addressing BC impact on air quality and climate.

Costabile, F., F. Angelini, F. Barnaba, & G.P. Gobbi (2015) *Partitioning of Black Carbon between ultrafine and fine particle modes in an urban airport vs. urban background environment*, ATMOSPHERIC ENVIRONMENT 102:136-144.

Characteristics of black carbon concentration at a metropolitan city located near land–ocean boundary in Eastern India

Abstract - Near surface aerosol black carbon (BC) concentration data were collected using a seven channel Aethalometer (AE31) during June 2012–May 2013 in Kolkata (22 34 E, 88 22 N), a metropolitan city located near the land–ocean boundary in Eastern India. BC concentration shows a prominent seasonal and diurnal variation associated with the meteorological parameters. The mean BC concentration varied from 5 g/m3 to 27 g/m3 seasonally. The variation of BC mass concentration and its significant association with atmospheric parameters such as temperature profile, relative humidity and wind speed have been studied. Moreover, the influence of the transported air masses on BC concentration at different seasons has also been discussed. An estimation of Angstrom exponent discloses that fossil fuel combustion is a major source of BC at this location.

Talukdar, S., S. Jana, A. Maitra, & M. M. Gogoi (2015) *Characteristics of black carbon concentration at a metropolitan city located near land–ocean boundary in Eastern India*, ATMOSPHERIC RESEARCH 153:526-534.

Blood pressure changes in association with black carbon exposure in a panel of healthy adults are independent of retinal microcirculation

Abstract - Exposure to ambient particulate matter and elevated blood pressure are risk factors for cardiovascular morbidity and mortality. Microvascular changes might be an important pathway in explaining the association between air pollution and blood pressure. The objective of the study was to evaluate the role of the retinal microcirculation in the association between black carbon (BC) exposure and blood pressure. We estimated subchronic BC exposure based on 1-week personal measurements (-Aethalometer, AethLabs) in 55 healthy nurses. Blood pressure and retinal microvasculature were measured on four different days (range: 2–4) during this week. Subchronic BC exposure averaged (SD) 1334 631 ng/m3 and ranged from 338 ng/m3 to 3889 ng/m3. An increased exposure of 631 ng/m3 BC was associated with a 2.77 mm Hg (95% CI: 0.39 to 5.15, p = 0.027) increase in systolic blood pressure, a 2.35 mm Hg (95% CI: 0.52 to 4.19, p = 0.016) increase in diastolic blood pressure and with 5.65 m (95% CI: 1.33 to 9.96, p = 0.014) increase in central retinal venular equivalent. Mediation analysis failed to reveal an effect of retinal microvasculature in the association between blood pressure and subchronic BC exposure. In conclusion, we found a positive association between blood pressure and subchronic black carbon exposure in healthy adults. This finding adds evidence to the association between black carbon exposure and cardiovascular health effects, with elevated blood pressure as a plausible intermediate effector. Our results suggest that the changes in a person's blood pressure as a result of subchronic black carbon exposure operate independently of the retinal microcirculation.

Louwies, T., T. Nawrot, B. Cox, E. Dons, J. Penders, E. Provost, L. I. Panis, & P. De Boever (2015) *Blood pressure changes in association with black carbon exposure in a panel of healthy adults are independent of retinal microcirculation*, ENVIRONMENT INTERNATIONAL 75:81-86.

Regionally-Varying Combustion Sources of the January 2013 Severe Haze Events over Eastern China

Abstract - Thick haze plagued northeastern China in January 2013, strongly affecting both regional climate and human respiratory health. Here, we present dual carbon isotope constrained (14C and

13C) source apportionment for combustion-derived black carbon aerosol (BC) for three key hotspot regions (megacities): North China Plain (NCP, Beijing), the Yangtze River Delta (YRD, Shanghai), and the Pearl River Delta (PRD, Guangzhou) for January 2013. BC, here quantified as elemental carbon (EC), is one of the most health-detrimental components of PM2.5 and a strong climate warming agent. The results show that these severe haze events were equally affected (~30%) by biomass combustion in all three regions, whereas the sources of the dominant fossil fuel component was dramatically different between north and south. In the NCP region, coal combustion accounted for 66% (46 74%, 95% C.I.) of the EC, whereas, in the YRD and PRD regions, liquid fossil fuel combustion (e.g., traffic) stood for 46% (18 66%) and 58% (38 68%), respectively. Taken together, these findings suggest the need for a regionally-specific description of BC sources in climate models and regionally-tailored mitigation to combat severe air pollution events in East Asia.

August Andersson, Junjun Deng, Ke Du, Mei Zheng, Caiqing Yan, Martin Sköld, and Örjan Gustafsson (2015) Regionally-Varying Combustion Sources of the January 2013 Severe Haze Events over Eastern China, Environ. Sci. Technol. 49(4):2038–2043.

HYDROFLUOROCARBONS & ALTERNATIVES

Deposition and rainwater concentrations of trifluoroacetic acid in the United States from the use of HFO-1234yf

Abstract - Currently, HFC-134a (1,1,1,2-tetrafluoroethane) is the most common refrigerant in automobile air conditioners. This high global warming potential substance (100 year GWP of 1370) will likely be phased out and replaced with HFO-1234yf (2,3,3,3-tetrafluoropropene) that has a 100 year GWP of 4. HFO-1234yf will be oxidized to produce trifluoroacetic acid (TFA) in clouds. TFA, a mildly toxic substance with detrimental effects on some aquatic organisms at high concentrations (100 gL 1), would be transported by rain to the surface and enter bodies of water. We investigated the dry and wet deposition of TFA from HFO-1234yf over the contiguous USA using the Advanced Research Weather Research and Forecasting model (ARW) with interactive chemical, aerosol, and cloud processes (WRF/Chem) model. Special focus was placed on emissions from three continental USA regions with different meteorological characteristics. WRF/Chem simulated meteorology, cloud processes, gas and aqueous phase chemistry, and dry and wet deposition between May and September 2006. The model reproduced well the multimonth total sulfate wet deposition (4% bias) and its spatial variability (r = 0.86) observed by the National Atmospheric Deposition Program. HFO-1234yf emissions were obtained by assuming the number of automobile air conditioners to remain unchanged, and substituting HFO-1234yf, mole-per-mole for HFC-134a. Our estimates of current HFC-134a emissions were in agreement with field data. Average TFA rainwater concentration was 0.89 gL 1, with peak values of 7.8 gL 1, for the May–September 2006 period over the contiguous USA. TFA rainwater concentrations over the dry western USA were often significantly higher, but wet-deposited TFA amounts remained relatively low at such locations.

Kazil1, J., S. McKeen, S.-W. Kim, R. Ahmadov, G. A. Grell, R. K. Talukdar, & A. R. Ravishankara (2014) Deposition and rainwater concentrations of trifluoroacetic acid in the United States from the use of HFO-1234yf, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(24):14,059–14,079.

U.S. emissions of HFC-134a derived for 2008–2012 from an extensive flask-air sampling network

Abstract - U.S. national and regional emissions of HFC-134a are derived for 2008–2012 based on atmospheric observations from ground and aircraft sites across the U.S. and a newly developed regional inverse model. Synthetic data experiments were first conducted to optimize the model assimilation design and to assess model-data mismatch errors and prior flux error covariances computed using a maximum likelihood estimation technique. The synthetic data experiments also tested the sensitivity of derived national and regional emissions to a range of assumed prior emissions, with the goal of designing a system that was minimally reliant on the prior. We then

explored the influence of additional sources of error in inversions with actual observations, such as those associated with background mole fractions and transport uncertainties. Estimated emissions of HFC-134a range from 52 to 61 Gg yr 1 for the contiguous U.S. during 2008–2012 for inversions using air transport from Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model driven by the 12 km resolution meteorogical data from North American Mesoscale Forecast System (NAM 12) and all tested combinations of prior emissions and background mole fractions. Estimated emissions for 2008–2010 were 20% lower when specifying alternative transport from Stochastic Time-Inverted Lagrangian Transport (STILT) model driven by the Weather Research and Forecasting (WRF) meteorology. Our estimates (for HYSPLIT-NAM 12) are consistent with annual emissions reported by U.S. Environmental Protection Agency for the full study interval. The results suggest a 10–20% drop in U.S. national HFC-134a emission in 2009 coincident with a reduction in transportation-related fossil fuel CO_2 emissions, perhaps related to the economic recession. All inversions show seasonal variation in national HFC-134a emissions in all years, with summer emissions greater than winter emissions by 20–50%.

Hu, L., S. A. Montzka, J. B. Miller, A. E. Andrews, S. J. Lehman, B. R. Miller, K. Thoning, C. Sweeney, H, Chen, D. S. Godwin, K. Masarie, L. Bruhwiler, M. L. Fischer, S. C. Biraud, M. S. Torn, M. Mountain, T. Nehrkorn, J. Eluszkiewicz, S. Miller, R. R. Draxler, A. F. Stein, B. D. Hall, J. W. Elkins, & P. P. Tans (2015) U.S. emissions of HFC-134a derived for 2008–2012 from an extensive flask-air sampling network, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Early View).

Analysis based on EU Regulation No 517/2014 of new HFC/HFO mixtures as alternatives of high GWP refrigerants in refrigeration and HVAC systems

Abstract - The EU Regulation No 517/2014 is going to phase-out most of the refrigerants commonly used in refrigeration and air conditioning systems (R134a, R404A and R410A) because of their extended use and their high GWP values. There are very different options to replace them; however, no refrigerant has yet imposed. In this paper we review and analyze the different mixtures proposed by the AHRI as alternative refrigerants to those employed currently. These mixtures are composed by HFC refrigerants: R32, R125, R152a and R134a; and HFO refrigerants: R1234yf and R1234ze(E). It is concluded, from the theoretical analysis, that most of the new HFO/HFC mixtures perform under the HFC analyzed (although some experimental studies show the contrary) and, in most cases, do not meet the GWP restrictions approved by the European normative. Furthermore, some of the mixtures proposed would have problems due to their flammability.

Mota-Babiloni, A., J. Navarro-Esbrí, Á. Barragán-Cervera, F. Molés, & B. Peris (2015) Analysis based on EU Regulation No 517/2014 of new HFC/HFO mixtures as alternatives of high GWP refrigerants in refrigeration and HVAC systems, INTERNATIONAL JOURNAL OF REFRIGERATION 52:21-31.

Experimental study of an R1234ze(E)/R134a mixture (R450A) as R134a replacement

Abstract - This work presents an experimental analysis of a non-flammable R1234ze(E)/R134a mixture (R450A) as R134a drop-in replacement. While R134a has a high GWP value (1430), the R450A GWP is only 547. The experimental tests are carried out in a vapour compression plant equipped with a variable-speed compressor. The replacement suitability has been studied combining different operating conditions: evaporation temperature, condensation temperature and the use of an internal heat exchanger (IHX). The drop-in cooling capacity of R450A compared with R134a is 6% lower as average. R450A COP is even higher to those resulting with R134a (approximately 1%). The discharge temperature of R450A is lower than that of R134a, 2K as average. The IHX has a similar positive influence on the energy performance of both fluids. In conclusion, R450A can be considered as a good candidate to replace R134a.

Mota-Babiloni, A., J. Navarro-Esbrí, Á. Barragán-Cervera, F. Molés, & B. Peris (2015) Experimental study of an R1234ze(E)/R134a mixture (R450A) as R134a replacement, INTERNATIONAL JOURNAL OF REFRIGERATION 51:52-58.

Projections of summertime ozone concentration over East Asia under multiple IPCC SRES emission scenarios

Abstract - We have developed the Integrated Climate and Air Quality Modeling System (ICAMS) through the one-way nesting of global–regional models to examine the changes in the surface ozone concentrations over East Asia under future climate scenarios. Model simulations have been conducted for the present period of 1996–2005 to evaluate the performance of ICAMS. The simulated surface ozone concentrations reproduced the observed monthly mean concentrations at sites in East Asia with high R2 values (0.4–0.9), indicating a successful simulation to capture both spatial and temporal variability. We then performed several model simulations with the six IPCC SRES scenarios (A2, A1B, A1FI, A1T, B1, and B2) for the next three periods, 2016–2025 (the 2020s), 2046–2055 (the 2050s), and 2091–2100 (the 2090s). The model results show that the projected changes of the annual daily mean maximum eight-hour (DM8H) surface ozone concentrations in summertime for East Asia are in the range of 2–8 ppb, 3 to 8 ppb, and 7 to 9 ppb for the 2020s, the 2050s, and the 2090s, respectively, and are primarily determined based on the emission changes of NOx and NMVOC. The maximum increases in the annual DM8H surface ozone and high-ozone events occur in the 2020s for all scenarios except for A2, implying that the air quality over East Asia is likely to get worse in the near future period (the 2020s) than in the far future periods (the 2050s and the 2090s). The changes in the future environment based on IPCC SRES scenarios would also influence the change in the occurrences of high-concentrations events more greatly than that of the annual DM8H surface ozone concentrations. Sensitivity simulations show that the emissions increase is the key factor in determining future regional surface ozone concentrations in the case of a developing country, China, whereas a developed country, Japan would be influenced more greatly by effects of the regional climate change than the increase in emissions.

Lee, J.-B., J. Cha, S. Hong, J. Choi, J. Myoung, R. J. Park, J. Woo, C. Ho, J. Han, & C. Song (2015) Projections of summertime ozone concentration over East Asia under multiple IPCC SRES emission scenarios, ATMOSPHERIC ENVIRONMENT *106:335-346.*

Seasonal behavior and long-term trends of tropospheric ozone, its precursors and chemical conditions over Iran: A view from space

Abstract - To identify spatial and temporal variations over the Iranian region, this study analyzed tropospheric formaldehyde (HCHO) and nitrogen dioxide (NO2) columns from Ozone Monitoring Instrument (OMI), carbon monoxide (CO) columns from the Measurement of Pollution in the Troposphere (MOPITT), and tropospheric column O3 (TCO) from OMI/MLS (Microwave Limb Sounder) satellites from 2005 to 2012. The study discovered high levels of HCHO (~12   1015 molec./cm2) from plant isoprene emissions in the air above parts of the northern forest of Iran during the summer and from the oxidation of HCHO precursors emitted from petrochemical industrial facilities and biomass burning in South West Iran. This study showed that maximum NO2 levels (~18   1015 molec./cm2) were concentrated in urban cities, indicating the predominance of anthropogenic sources. The results indicate that maximum concentrations were found in the winter, mainly because of weaker local winds and higher heating fuel consumption, in addition to lower hydroxyl radicals (OH). The high CO concentrations (~2   1018 molec./cm2) in the early spring were inferred to mainly originate from a strong continental air mass from anthropogenic CO "hotspots" including regions around Caspian Sea, Europe, and North America, although the external sources of CO were partly suppressed by the Arabian anticyclone and topographic barriers. Variations in the TCO were seen to peak during the summer (~40 DU), due to intensive solar radiation and stratospheric sources. This study also examined long-term trends in TCO and its precursors over a period of eight years in five urban cities in Iran. To perform the analysis, we estimated seasonal changes and inter-seasonal variations using least-squares harmonic estimation (LS-HE), which reduced uncertainty in the trend by 5–15%. The results showed significant increases in the levels of HCHO (~0.08   0.06   1015 molec./cm2 yr 1), NO2 (~0.08   0.02   1015 molec./cm2 yr 1), and peak annual TCO (~0.59   0.56 DU yr 1) but decreases in minimum annual TCO (~ 0.42   0.60 DU yr 1) caused by an increase in

NO2 species and annual CO (~ 0.95   0.41   1016 molec./cm2 yr 1) partly resulting from the transport of reduced CO. The time series of the HCHO/NO2 column ratio (a proxy for the chemical conditions) indicated that during the last decade, the cities of Tehran, Ahvaz, and Isfahan exhibited steady chemical conditions while Tabriz and Mashhad exhibited a change from NOx-saturated/mixed to more NOx-sensitive chemical conditions.

Choi, Y., & A. H. Souri (2015) Seasonal behavior and long-term trends of tropospheric ozone, its precursors and chemical conditions over Iran: A view from space, ATMOSPHERIC ENVIRONMENT 106:232-240.

Global impacts of surface ozone changes on crop yields and land use

Abstract - Exposure to surface ozone has detrimental impacts on vegetation and crop yields. In this study, we estimate ozone impacts on crop production and subsequent impacts on land use in the 2005–2050 period using results of the TM5 atmospheric chemistry and IMAGE integrated assessment model. For the crops represented in IMAGE, we compute relative yield losses based on published exposure-response functions. We examine scenarios with either constant or declining emission factors in a weak climate policy future (radiative forcing target of 6.0 W/m2 at the end of the century), as well as co-benefits of stringent climate policy (targeted at 2.6 W/m2). Without a large decrease in air pollutant emissions, higher ozone concentrations could lead to an increase in crop damage of up to 20% locally in 2050 compared to the situation in which the changes in ozone are not accounted for. This may lead to a 2.5% global increase in crop area, and a regional increase of 8.9% in Asia. Implementation of air pollution policies could limit crop yield losses due to ozone to maximally 10% in 2050 in the most affected regions. Similar effects can be obtained as a result of co-benefits from climate policy (reducing ozone precursor emissions). We also evaluated the impact of the corresponding land-use changes on the carbon cycle. Under the worst-case scenario analysed in this study, future ozone increases are estimated to increase the cumulative net CO2 emissions between 2005 and 2050 by about 3.7 Pg C, which corresponds to about 10% of baseline land use emissions over the same period.

Chuwah, C., T. van Noije, D. P. van Vuuren, E. Stehfest, & W. Hazeleger (2015) Global impacts of surface ozone changes on crop yields and land use, Atmospheric Environment, Volume 106, April 2015, Pages 11-23.

Investigation into relationships among NO, NO2, NOX, O3, and CO at an urban background site in Delhi, India

Abstract - High resolution concentrations of nitric oxide (NO), nitrogen dioxide (NO2), oxides of nitrogen (NOx), and Ozone (O3) were measured at a urban site (urban background) in New Delhi, India for a period of two years from September 2010 to August 2012. During this study period, the mean concentrations of NO, NO2, NOx, O3 (ppb), and CO (ppm) were observed to be 17.2, 12.5, 29.3, 23.6, and 1.97, respectively. This data was then employed to investigate the relationships between NO, NO2, and O3 as a function of NOx. The highest mean concentrations of NO were observed from midnight 00:00 to 05:00 h local time (LT) in the morning as a result of increase in traffic emissions and a reduction in boundary layer height during the night. The total levels of oxidant [OX], which are considered to be the sum of O3 and NO2, were determined. A study of variation of [OX] and NOx identified two distinct contributions to ambient OX concentrations, i.e., NOx independent and NOx dependent. The NOx-dependent contribution corresponds to the local production of ozone, and the NOx-independent contribution corresponds to regional concentrations, which at this site is the background level of ozone. The monthly and diurnal variations of [OX] are discussed. Wind directions were used to identify possible regional source of [OX]. The analysis suggests that [OX] concentrations were about six times higher with winds originating from the Northwest direction (NW) compared to those from the East.

Tiwari, S., A. Dahiya, & N. Kumar (2015) Investigation into relationships among NO, NO2, NOX, O3, and CO at an urban background site in Delhi, India, ATMOSPHERIC RESEARCH (In Press).

Simulation of ozone formation at different elevations in mountainous area of Hong Kong using WRF-CMAQ model

Abstract - Field measurements were simultaneously conducted at a mountain (Mt.) site (Tai Mao Shan, TMS) and an urban site (Tsuen Wan, TW) at the foot of the Mt. TMS in Hong Kong. An interesting event with consecutive high-ozone (O3) days from 08:00 on 28 Oct. to 23:00 on 03 Nov., 2010 was observed at Mt. TMS, while no such polluted event was found at the foot of the mountain. The Weather Research and Forecasting (WRF)-Community Multiscale Air Quality (CMAQ) models were used to understand this event. Model performance evaluation showed that the simulated meteorological parameters and air pollutants were well in agreement with the observations. The index of agreement (IOA) of temperature, relative humidity, wind direction and wind speed were 0.93, 0.83, 0.46 and 0.60, respectively. The multi-day high O3 episode at Mt. TMS was also reasonably reproduced (IOA = 0.68). Horizontally, the photochemical processes determined the O3 levels in southwestern Pearl River Delta (PRD) and the Pearl River Estuary (PRE), while in eastern and northern PRD, the O3 destruction was over the production during the event. Vertically, higher O3 values at higher levels were found at both Mt. TMS and TW, indicating a vertical O3 gradient over Hong Kong. With the aid of the process analysis module, we found positive contribution of vertical transport including advection and diffusion to O3 mixing ratios at the two sites, suggesting that O3 values at lower locations could be affected by O3 at higher locations via vertical advection and diffusion over Hong Kong.

Wang, N., H. Guo, F. Jiang, Z.H. Ling, T. Wang (2015) Simulation of ozone formation at different elevations in mountainous area of Hong Kong using WRF-CMAQ model, SCIENCE OF THE TOTAL ENVIRONMENT 505:939-951.

Projecting policy-relevant metrics for high summertime ozone pollution events over the eastern United States due to climate and emission changes during the 21st century

Abstract - Over the eastern United States (EUS), nitrogen oxides (NOx) emission controls have led to improved air quality over the past two decades, but concerns have been raised that climate warming may offset some of these gains. Here we analyze the effect of changing emissions and climate, in isolation and combination, on EUS summertime surface ozone (O3) over the recent past and the 21st century in an ensemble of simulations performed with the Geophysical Fluid Dynamics Laboratory CM3 chemistry-climate model. The simulated summertime EUS O3 is biased high but captures the structure of observed changes in regional O3 distributions following NOx emission reductions. We introduce a statistical bias correction, which allows derivation of policy-relevant statistics by assuming a stationary mean state bias in the model, but accurate simulation of changes at each quantile of the distribution. We contrast two different 21st century scenarios: (i) representative concentration pathway (RCP) 4.5 and (ii) simulations with well-mixed greenhouse gases (WMGG) following RCP4.5 but with emissions of air pollutants and precursors held fixed at 2005 levels (RCP4.5_WMGG). We find under RCP4.5 no exceedance of maximum daily 8 hour average ozone above 75 ppb by mid-21st century, reflecting the U.S. NOx emissions reductions projected in RCP4.5, while more than half of the EUS exceeds this level by the end of the 21st century under RCP4.5_WMGG. Further, we find a simple relationship between the changes in estimated 1 year return levels and regional NOx emission changes, implying that our results can be generalized to estimate changes in the frequency of EUS pollution events under different regional NOx emission scenarios.

Rieder, H. E., A. M. Fiore, L. W. Horowitz, & V. Naik (2015) Projecting policy-relevant metrics for high summertime ozone pollution events over the eastern United States due to climate and emission changes during the 21st century, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES.

Comprehensive study of emission source contributions for tropospheric ozone formation over East Asia

Abstract - Emission source contributions of tropospheric ozone (O3) were comprehensively investigated by using the higher-order decoupled direct method (HDDM) for sensitivity analysis and the ozone source apportionment technology (OSAT) for mass balance analysis in the comprehensive air-quality model with extensions (CAMx). The response of O3 to emissions reductions at various levels in mainland China, Korea, and Japan were estimated and compared with results calculated by the brute force method (BFM) where one model parameter is varied at a time. Emissions were

assessed at three receptor sites in Japan that experienced severe pollution events in May 2009. For emissions from China, HDDM assessed O3 response with a bias of only up to 3 ppbv (a relative error of 4.5%) even for a 50% reduction but failed to assess a more extreme reduction. OSAT was reasonably accurate at 100% reduction, with a 4 ppbv (7%) bias, but was less accurate at moderate ranges of reduction (~50–70%). For emissions from Korea and Japan, HDDM captured the nonlinear response at all receptor sites and at all reduction levels to within 1% in all but one case; however, the bias of OSAT increased with the increasing reduction of emissions. One possible reason for this is that OSAT does not account for NO titration. To address this, a term for potential ozone (PO; O3 and NO2 together) was introduced. Using of PO instead of O3 improved the performance of OSAT, especially for emissions reductions from Korea and Japan. The proposed approach with PO refined the OSAT results and did not degrade HDDM performance.

Itahashi, S., H. Hayami, & I. Uno (2015) *Comprehensive study of emission source contributions for tropospheric ozone formation over East Asia*, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 120(1):331–358.

PARTICULATE MATTER AIR POLLUTION

Aerosol remote sensing in polar regions

Abstract - Multi-year sets of ground-based sun-photometer measurements conducted at 12 Arctic sites and 9 Antarctic sites were examined to determine daily mean values of aerosol optical thickness ( ) at visible and near-infrared wavelengths, from which best-fit values of Ångström's exponent   were calculated. Analysing these data, the monthly mean values of (0.50 m) and   and the relative frequency histograms of the daily mean values of both parameters were determined for winter–spring and summer–autumn in the Arctic and for austral summer in Antarctica. The Arctic and Antarctic covariance plots of the seasonal median values of   versus (0.50 m) showed: (i) a considerable increase in (0.50 m) for the Arctic aerosol from summer to winter–spring, without marked changes in ; and (ii) a marked increase in (0.50 m) passing from the Antarctic Plateau to coastal sites, whereas   decreased considerably due to the larger fraction of sea-salt aerosol. Good agreement was found when comparing ground-based sun-photometer measurements of ( ) and   at Arctic and Antarctic coastal sites with Microtops measurements conducted during numerous AERONET/MAN cruises from 2006 to 2013 in three Arctic Ocean sectors and in coastal and off-shore regions of the Southern Atlantic, Pacific, and Indian Oceans, and the Antarctic Peninsula.

Lidar measurements were also examined to characterise vertical profiles of the aerosol backscattering coefficient measured throughout the year at Ny-Ålesund. Satellite-based MODIS, MISR, and AATSR retrievals of ( ) over large parts of the oceanic polar regions during spring and summer were in close agreement with ship-borne and coastal ground-based sun-photometer measurements. An overview of the chemical composition of mode particles is also presented, based on in-situ measurements at Arctic and Antarctic sites. Fourteen log-normal aerosol number size-distributions were defined to represent the average features of nuclei, accumulation and coarse mode particles for Arctic haze, summer background aerosol, Asian dust and boreal forest fire smoke, and for various background austral summer aerosol types at coastal and high-altitude Antarctic sites. The main columnar aerosol optical characteristics were determined for all 14 particle modes, based on in-situ measurements of the scattering and absorption coefficients. Diurnally averaged direct aerosol-induced radiative forcing and efficiency were calculated for a set of multimodal aerosol extinction models, using various Bidirectional Reflectance Distribution Function models over vegetation-covered, oceanic and snow-covered surfaces. These gave a reliable measure of the pronounced effects of aerosols on the radiation balance of the surface–atmosphere system over polar regions.

Tomasi, C., A. A. Kokhanovsky, A. Lupi, C. Ritter, A. Smirnov, N. T. O'Neill, R. S. Stone, B. N. Holben, S. Nyeki, C. Wehrli, A. Stohl, M. Mazzola, C. Lanconelli, V. Vitale, K. Stebel, V. Aaltonen, G. de Leeuw, E. Rodriguez, A. B. Herber, V. F. Radionov, & T. Zielinski (2015) *Aerosol remote sensing in polar regions*, EARTH-SCIENCE REVIEWS 140:108-157.

Long-term trend of airborne particulate matter in Seoul, Korea from 2004 to 2013

Abstract - In this study, the pollution status of particulate matter (PM) in ambient air was investigated based on the concentration data of three important PM fractions (PM2.5, PM10, and TSP) measured from a central area in Seoul, Korea during the period from 2004 to 2013. The mean concentrations of each fraction measured for the entire study period were found to be 26.6 ± 2.59, 54.0 ± 15.0, and 75.3 ± 16.6 μg m⁻³, respectively. The seasonal mean of PM2.5 varied in the range of 22.9 ± 7.10 (fall) to 30.2 ± 7.58 μg m⁻³ (winter). In contrast, PM10 and TSP showed a summer minimum (40.1 ± 12.6 and 55.6 ± 17.8 μg m⁻³, respectively) and a spring maximum (67.1 ± 16.7 and 93.7 ± 21.1 μg m⁻³, respectively). The contribution of regional or long-range transport to the observed PM levels in the study area, if estimated by comparison to the data of the regional background area, was found to explain up to 72% of its input. The long-term trend of PM indicated a gradual decreasing pattern over a 10 year period, although that of PM2.5 was rather complicated to interpret in the recent years. The overall results of our study nonetheless confirm the potent role of legislation efforts put consistently to improve the air quality through the years.

Ahmed, E., K.-H. Kim, Z.-H. Shon, & S.-K. Song (2015) Long-term trend of airborne particulate matter in Seoul, Korea from 2004 to 2013, ATMOSPHERIC ENVIRONMENT *101:125-133.*

Control of PM2.5 in Guangzhou during the 16th Asian Games period: Implication for hazy weather prevention

Abstract - To evaluate the effectiveness of the integrated control measures for reducing PM2.5 (aerosol particles with an aerodynamic diameter of less than 2.5 μm) and hazy weather, day- and night-time PM2.5 samples were collected at an urban site in Guangzhou during the 16th Asian Games period in November 2010. PM2.5 samples were subject to chemical analysis for major water-soluble ions, organic carbon (OC), element carbon (EC), and biomass burning tracers–anhydrosugar levoglucosan (LG). In addition, aerosol scattering coefficient (bsp) at dry condition and aerosol absorption coefficient (bap) and visibility at ambient condition were measured. The seven major control measures were effective for reducing PM2.5 mass concentration and improving visibility during the Asian Games period. All monitored air pollutants except PM2.5 satisfied the National Ambient Air Quality Standards (NAAQS). However, daily PM2.5 concentrations still exceeded the NAAQS on 47% of the days and hazy weather also occurred on 80% of the days during this period.

One factor causing the high frequency of hazy weather occurrence was the increased relative humidity during the Asian Games period. To avoid hazy weather occurrence, new PM2.5 standard was recommended based on visibility calculations using three available aerosol hygroscopic curves previously obtained for this city. The recommended PM2.5 standard was 63 μg m⁻³ under dry condition and lower than 42 μg m⁻³ under humid condition (RH ≥ 70%). These recommended values were much stricter than the NAAQS value of 75 μg m⁻³. To reach the new standard, more rigorous control measures for coal industries should be established in the Pearl River Delta (PRD) region.

Tao, J., L. Zhang, Z. Zhang, R. Huang, Y. Wu, R. Zhang, J. Cao, Y. Zhang (2015) Control of PM2.5 in Guangzhou during the 16th Asian Games period: Implication for hazy weather prevention, SCIENCE OF THE TOTAL ENVIRONMENT *508:57-66.*

Using Single Scattering Albedo Spectral Curvature to Characterize East Asian Aerosol Mixtures

Abstract - Spectral dependence of aerosol Single Scattering Albedo (SSA) has been used to infer aerosol composition. In particular, aerosol mixtures dominated by dust absorption will have monotonically increasing SSA with wavelength while that dominated by black carbon absorption has monotonically decreasing SSA spectra. However, by analyzing SSA measured at four wavelengths: 440 nm, 675 nm, 870 nm and 1020 nm from the AERONET dataset, we find that the SSA spectra over East Asia are frequently peaked at 675 nm. In these cases, we suggest that SSA spectral curvature, defined as the negative of the second derivative of SSA as a function of wavelength, can provide additional information on the composition of these aerosol mixtures. Aerosol SSA spectral curvatures for East Asia during fall and winter are considerably larger than those found in places primarily dominated by biomass burning or dust aerosols. SSA curvature is found to increase as the SSA magnitude decreases.

The curvature increases with coarse mode fraction (CMF) to a CMF value of about 0.4, then slightly decreases or remains constant at larger CMF. Mie calculations further verify that the strongest SSA curvature occurs at ~40% dust fraction, with 10% scattering aerosol fraction. The non-monotonic SSA spectral dependence is likely associated with enhanced absorption in the shortwave by dust, absorption by black carbon at longer wavelengths, and also the flattened AOD spectral dependence due to the increased particle size.

Li, J., B. E. Carlson & A. A. Lacis (2015) Using Single Scattering Albedo Spectral Curvature to Characterize East Asian Aerosol Mixtures, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Accepted Article).

Uncertainty in the magnitude of aerosol-cloud radiative forcing over recent decades

Abstract - Aerosols and their effect on the radiative properties of clouds are one of the largest sources of uncertainty in calculations of the Earth's energy budget. Here the sensitivity of aerosol-cloud albedo effect forcing to 31 aerosol parameters is quantified. Sensitivities are compared over three periods; 1850–2008, 1978–2008, and 1998–2008. Despite declining global anthropogenic SO2 emissions during 1978–2008, a cancelation of regional positive and negative forcings leads to a near-zero global mean cloud albedo effect forcing. In contrast to existing negative estimates, our results suggest that the aerosol-cloud albedo effect was likely positive (0.006 to 0.028Wm 2) in the recent decade, making it harder to explain the temperature hiatus as a forced response. Proportional contributions to forcing variance from aerosol processes and natural and anthropogenic emissions are found to be period dependent. To better constrain forcing estimates, the processes that dominate uncertainty on the timescale of interest must be better understood.

Regayre, L. A., K. J. Pringle, B. B. B. Booth, L. A. Lee, G. W. Mann, J. Browse, M. T. Woodhouse, A. Rap, C. L. Reddington, & K. S. Carslaw (2015) Uncertainty in the magnitude of aerosol-cloud radiative forcing over recent decades, GEOPHYSICAL RESEARCH LETTERS, 41(24):9040–9049.

Assimilation of next generation geostationary aerosol optical depth retrievals to improve air quality simulations

Abstract - Planned geostationary satellites will provide aerosol optical depth (AOD) retrievals at high temporal and spatial resolution which will be incorporated into current assimilation systems that use low-Earth orbiting (e.g., Moderate Resolution Imaging Spectroradiometer (MODIS)) AOD. The impacts of such additions are explored in a real case scenario using AOD from the Geostationary Ocean Color Imager (GOCI) on board of the Communication, Ocean, and Meteorology Satellite, a geostationary satellite observing northeast Asia. The addition of GOCI AOD into the assimilation system generated positive impacts, which were found to be substantial in comparison to only assimilating MODIS AOD. We found that GOCI AOD can help significantly to improve surface air quality simulations in Korea for dust, biomass burning smoke, and anthropogenic pollution episodes when the model represents the extent of the pollution episodes and retrievals are not contaminated by clouds. We anticipate future geostationary missions to considerably contribute to air quality forecasting and provide better reanalyses for health assessments and climate studies.

Saide, P. E., J. Kim, C. H. Song, M. Choi, Y. Cheng, & G. R. Carmichael (2014) Assimilation of next generation geostationary aerosol optical depth retrievals to improve air quality simulations, GEOPHYSICAL RESEARCH LETTERS 41(24):9188–9196.

Aerosols and trace gases characterization over Indo-Gangetic plain in semiarid region

Abstract - This paper deals with measurements of aerosols, their chemical properties and precursor trace gases at Agra in the Indo-Gangetic plain. The average TSPM level is 441.2 g m 3 and ranges between 60.8 g m 3 and 1004.6 g m 3 which are higher than National Ambient Air Quality Standard Values of India. High wind speed from North West direction influences the aerosol load. TSPM load is higher during prefoggy/foggy days and lower during post foggy days. NH4+ concentration is highest followed by NO3 , SO42 , Cl , K+, Ca2+, Na+, Mg2+ and F . The high concentration of NH4+ may be probably due to nearby cattle yard, use of fertilizers and biogenic emissions. The concentration of trace gases SO2, NO2, HNO3 and NH3 are 20.8 g m 3, 26.3 g m 3, 1.6 g m 3, 18.6 g m 3,

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respectively. The transportation of urban plumes may be responsible for high concentration of SO_2 and NO_2. HNO_3/NO_3 ratio is less than unity. There was no correlation between SO_2 and SO_4^2. The ratio of SO_4^2 + NO_3 + Cl/NH_4+ are 1.8 and 2.3, respectively indicate that acidifying components are not neutralized only by NH_4+ ion.

Kumar, R., & K. M. Kumari (2015) *Aerosols and trace gases characterization over Indo-Gangetic plain in semiarid region*, URBAN CLIMATE 12:11-20.

Outdoor infiltration and indoor contribution of UFP and BC, OC, secondary inorganic ions and metals in PM2.5 in schools

Abstract - Infiltration of outdoor-sourced particles into indoor environments in 39 schools in Barcelona was assessed during school hours. Tracers of road traffic emissions (NO_2, Equivalent Black Carbon (EBC), Ultrafine Particles (UFP), Sb), secondary inorganic aerosols (SO_4^2, NO_3, NH_4+) and a number of PM2.5 trace elements showed median indoor/outdoor (I/O) ratios 1, indicating that outdoor sources importantly contributed to indoor concentrations. Conversely, OC and mineral components had I/O ratios>1. Different infiltration factors were found for traffic and secondary components (0.31–0.75 and 0.50–0.92, cold and warm season respectively), with maxima corresponding to EBC and Cd. Higher concentrations of indoor-generated particles were observed when closed windows hindered dispersion (cold season). Building age was not a major determinant of indoor levels. Neither were the window's material, except for NO_2 (with an increase of 8 g m 3 for wood framed windows) and the mineral components (also dependent on the presence of sand in a distance <20 m) that reach the indoor environment via soil adhering to footwear with their dispersion being more barred by Aluminium/PVC framed windows than the wooden ones. Enlarged indoor concentrations of some trace elements suggest the presence of indoor sources that should be further investigated in order to achieve a healthier school indoor environment.

Rivas, I., M. Viana, T. Moreno, L. Bouso, M. Pandolfi, M. Alvarez-Pedrerol, J. Forns, A. Alastuey, J. Sunyer, & X. Querol (2015) *Outdoor infiltration and indoor contribution of UFP and BC, OC, secondary inorganic ions and metals in PM2.5 in schools*, ATMOSPHERIC ENVIRONMENT 106:129-138.

Source apportionment of PM2.5 carbonaceous aerosol in Baghdad, Iraq

Abstract - Baghdad is the second largest city in the Middle East and suffers from severe air quality degradation due to the high levels of the atmospheric particulate matter (PM). Limited information exists regarding the sources of PM in Baghdad, and the lack of information on sources inhibits the development of control strategies to reduce air pollution. To better understand the nature of fine particulate matter (PM2.5) in Baghdad and the Middle East, a one year sampling campaign to collect PM2.5 was conducted from September 2012 through September 2013, missing August 2013 samples due to the security situation. 24-hour integrated samples collected on a 1-in-6 day schedule were analyzed for the major components, and monthly average samples were analyzed by gas chromatography mass spectrometry (GCMS) methods to measure particle-phase organic molecular markers. The results of organic molecular markers were used in a chemical mass balance (CMB) model to quantify the sources of PM2.5 organic carbon (OC) and PM2.5 mass. Primary sources accounted for 44% of the measured PM2.5, and secondary sources were estimated to make up 28% of the measured PM2.5. Picene, a tracer of coal combustion detected in Baghdad where there is no evidence for coal combustion, can be attributed to burning crude oil and other low quality fuels in Baghdad. Source apportionment results showed that the dominant sources of the carbonaceous aerosols in Baghdad are gasoline (37 6%) and diesel engines (17 3%) which can be attributed to the extensive use of gasoline and diesel powered generators in Baghdad. Wood burning and residual oil combustion contributed to 5 0.4 and 1 0.2% respectively of OC. The unresolved sources contributed to 42 19% of the OC which represented the secondary organic aerosol (SOA) and the unidentified sources.

Hamad, S. H., J. J. Schauer, J. Heo, & A. K. H. Kadhim (2015) *Source apportionment of PM2.5 carbonaceous aerosol in Baghdad, Iraq*, ATMOSPHERIC RESEARCH 156:80-90.

PM2.5 chemical composition in five European Mediterranean cities: A 1-year study

Abstract - The seasonal and spatial characteristics of PM2.5 and its chemical composition in the Mediterranean Basin have been studied over a 1-year period (2011–2012) in five European Mediterranean cities: Barcelona (BCN), Marseille (MRS), Genoa (GEN), Venice (VEN), and Thessaloniki (THE). During the year under study, PM10 annual mean concentration ranged from 23 to 46 g m 3, while the respective PM2.5 ranged from 14 to 37 g m 3, with the highest concentrations observed in THE and VEN. Both cities presented an elevated number of exceedances of the PM10 daily limit value, as 32% and 20% of the days exceeded 50 g m 3, respectively. Similarly, exceedances of the WHO guidelines for daily PM2.5 concentrations (25 g m 3) were also more frequent in THE with 78% of the days during the period, followed by VEN with 39%. The lowest PM levels were measured in GEN. PM2.5 exhibited significant seasonal variability, with much higher winter concentrations for VEN and MRS, in fall for THE and in spring for BCN. PM2.5 chemical composition was markedly different even for similar PM2.5 levels. On annual average, PM2.5 was dominated by OM except in THE. OM contribution was higher in Marseille (42%), while mineral matter was the most abundant constituent in THE (32%). Moreover, PM2.5 relative mean composition during pollution episodes (PM2.5 > 25 g m 3) as well as the origins of the exceedances were also investigated. Results outline mainly the effect of NO3 being the most important driver and highlight the non-negligible impact of atmospheric mixing and aging processes during pollution episodes.

Salameh, D., A. Detournay, J. Pey, N. Pérez, F. Liguori, D. Saraga, M. C. Bove, P. Brotto, F. Cassola, D. Massabò, A. Latella, S. Pillon, G. Formenton, S. Patti, A. Armengaud, D. Piga, J. L. Jaffrezo, J. Bartzis, E. Tolis, P. Prati, & X. Querol (2015) PM2.5 chemical composition in five European Mediterranean cities: A 1-year study, ATMOSPHERIC RESEARCH 155:102-117.

On the severe haze in Beijing during January 2013: Unraveling the effects of meteorological anomalies with WRF-Chem

Abstract - Despite the stringent emission reduction measures implemented in Beijing over the past decade, a series of unprecedentedly severe haze events hit this megacity in January 2013. It is of great interest to find out the cause so as to provide a scientific basis for refining emission control measures. In the present study, we examine long-term (2000–2014) surface meteorological observations and simulate four recent winter haze episodes in 2010–2014 using a coupled meteorology-chemistry model (WRF-Chem). In addition to confirming the large-scale meteorological anomalies in northern China, the analysis of local meteorological parameters revealed that January 2013 had more frequent sustained weak southerly winds and high relative humidity in Beijing. Comparison of WRF-Chem simulations of the four episodes unambiguously shows that the combination of anomalously strong contribution of local and regional sources resulted into the extreme event in 2013: meteorological anomalies caused thicker temperature inversion, lower boundary layer, and hence stronger local accumulation of PM2.5 in urban Beijing (212 g m 3 in 2013 case vs. 112–114 g m 3 in historical cases); longer duration of southerly winds transported more pollutants to urban area (107 g m 3 vs. 38–82 g m 3) from eastern China. Our study also suggests that, although the emissions in Beijing have been decreased, they were still the major contributor (61–77%) to surface-layer PM2.5 over the urban area in recent winter episodes. Since adverse weather conditions such as those in January 2013 are uncontrollable, to alleviate severe haze pollution, Beijing must further strengthen its emission reduction measures and similar control should be extended to the entire eastern China.

Zhang, L., T. Wang, M. Lv, & Q. Zhang (2015) On the severe haze in Beijing during January 2013: Unraveling the effects of meteorological anomalies with WRF-Chem, ATMOSPHERIC ENVIRONMENT 104:11-21.

Total and size-resolved particle number and black carbon concentrations in urban areas near Schiphol airport (the Netherlands)

Abstract - The presence of black carbon, and size-resolved and total particle number concentrations (PNC) were investigated in the vicinity of Schiphol airport in the Netherlands, the fourth busiest airport in Europe. Continuous measurements were conducted between March and May 2014 at Adamse Bos, located 7 km from Schiphol, and in 2012 at Cabauw, a regional background site 40 km

south of Schiphol. No significantly elevated black carbon levels were found near Schiphol. However, PNC increased during periods in which the wind direction was from Schiphol: at Cabauw by 20% and at Adamse Bos by a factor of three, from 14,100 (other wind directions) to 42,000 # cm 3 between 06.00 and 23.00. The size distribution of Schiphol-related PNC was dominated by ultrafine particles, ranging from 10 to 20 nm. Four relevant particle number (PN) emission sources at Schiphol were identified as being responsible for the elevated PNC levels at Adamse Bos: take-off and climb-out on the Kaagbaan and Aalsmeerbaan runways, planes waiting at the gates, and landing on the Buitenveldertbaan runway. PN emissions from road traffic at and near the airport were less important than air traffic. The exposure to Schiphol-related PNC in urban areas northeast of Schiphol in Amsterdam and Amstelveen was estimated for 2012 using a Gaussian Plume model. The results showed that a considerable number of the 555,000 addresses in the modelling domain were exposed to elevated PNC. For example: 45,000 addresses suffered long-term exposure to an additional annual background PNC of 5–10,000 # cm 3 originating from Schiphol and 60,000 addresses suffered short-term exposure (14% of the time) of additional 10–15,000 # cm 3 originating from Schiphol. Further research on emission sources and the dispersion of PN is recommended and may support future studies on eventual health effects.

Keuken, M. P., M. Moerman, P. Zandveld, J.S. Henzing, & G. Hoek (2015) Total and size-resolved particle number and black carbon concentrations in urban areas near Schiphol airport (the Netherlands), ATMOSPHERIC ENVIRONMENT 104:132-142.

Study of carbonaceous species, morphology and sources of fine (PM2.5) and coarse (PM10) particles along with their climatic nature in India

Abstract - The determination of particulate matter (PM2.5 and PM10) is very important due to its impact on climate, visibility reduction and natural environment. In order to identify their nature and relationship with the major synoptic-scale circulation patterns, particles were collected from Pune atmosphere and were analyzed in terms of morphology, carbonaceous species (organic and elemental carbon) and elemental concentration. Average mass concentrations of PM2.5 and PM10 were 104.57 25.70 g m 3 and 169.91 60.75 g m 3, respectively for the entire study period. This indicates that observed values of PM are substantially higher than NAAQS and WHO standards, respectively. The ratio between PM2.5 and PM10 was calculated and varied from 0.51 to 0.78 indicating abundance of fine particles over Pune during the study period. Carbonaceous analysis results showed that concentrations of OC and EC were 31.25 and 2.73 g m 3 for PM2.5 while 33.14 and 2.40 g m 3 for PM10, respectively. The calculated OC/EC ratios were 15.83 and 17.24 for PM2.5 and PM10, respectively indicating abundance of organic carbon which suggests the excess of secondary organic aerosols. The morphological traits such as circularity (< 1) and aspect ratio (> 1) were determined which indicate that the particles are not perfectly spherical and not elongated in any direction in both size ranges. Effective carbon ratio (ECR) an approach for climate was found to have an average value of 2.42 and 1.74 for PM2.5 and PM10. This clearly indicates that abundance of SOC and lower values of POC and EC could lead to the reduction in atmospheric warming effect due to combustion PM and increases scattering properties of incoming radiations. The monthly air mass backward trajectory cluster analysis was performed which supports the transport of aerosols from the long range transportation as well as the dominance of local sources over SW Indian region. The contribution of local sources was further determined which indicates that motor vehicle is the dominant emitter of carbonaceous aerosols in Pune.

Pipal, A. S., & P. G. Satsangi (2015) Study of carbonaceous species, morphology and sources of fine (PM2.5) and coarse (PM10) particles along with their climatic nature in India, ATMOSPHERIC RESEARCH 154:103-115.

Statistical modelling of aerosol particle number size distributions in urban and rural environments – A multi-site study

Abstract - A multiple linear regression approach was used to model the urban atmospheric particle number size distribution (NSD) at 11 different sites (roadside, urban background, rural) in Central European cities for the time period 2008–2010. The same set of 13 model input parameters, consisting of temporal information (daytime, season) and meteorological measurement data, was used at each site. NSD model performance indicates an average deviation between observations and model (Bias)

in the order of <10% with respect to total particle number concentration. The most reliable predictions were achieved for roadside sites with correlation coefficients (R) of 0.75 on average and a normalized root mean square error (RMSEn) of 0.79. Limited performance was observed for rural sites (R = 0.61; RMSEn ~ 1.2). The transferability of the model approach to an independent urban background site was tested showing R of 0.5 and normalized RMSEn of 1.4. Although the physical relationship between particle NSD, ambient meteorological conditions and the temporal parameters are extremely complex, the model was able to reproduce the variation in particle concentrations. As a first in the field this study focused on modelling the entire number size distribution in contrast to size integrated particle number concentrations.

von Bismarck-Osten, C., W. Birmili, M. Ketzel, & S. Weber (2015) Statistical modelling of aerosol particle number size distributions in urban and rural environments – A multi-site study, URBAN CLIMATE 11:51-66.

Trends of air pollution in the Western Mediterranean Basin from a 13-year database: A research considering regional, suburban and urban environments in Mallorca (Balearic Islands)

Abstract - This study is focused in the evolution of NO, NO2, SO2, O3 and PM10 concentrations, from 2000 to 2012, at urban, suburban and regional observatories in the Balearic Islands (Spain), an insular region in the Western Mediterranean. At urban and suburban areas, daily patterns of most pollutants are strongly linked to land-traffic emissions, being the regional background less influenced. SO2 variations, however, are mostly driven by the impact of other sources different from road traffic, including shipping emissions and power generation. Urban NOx, SO2 and PM10 concentrations exhibit a common weekly pattern, with a very slight accumulation during the weekdays and sharp decreases (15–39%) on weekends. Our long-term database displays clear decreasing NO and NO2 concentrations from 2000 onwards, prominent in the urban environment (1.1 g/m3 year), and moderate in suburban and regional areas (up to 0.3 g/m3 year). At urban sites, O3 behaviour (+1.0 g/m3 year) is opposite to that of NO, one of its main depletion agents. A moderate O3 increasing trend (+0.5 g/m3 year) is detected at regional background areas, whereas a modest decreasing trend occurred at the suburban background (0.4 g/m3 year), probably caused by enhanced vehicular emissions over these areas induced by urban planning and mobility policies. Finally, substantial PM10 drops are obvious, 0.7 g/m3 year at urban and suburban areas, and 0.5 g/m3 year in the regional background. Our results link the sharpest declines to air masses from western to northern sectors, pointing to effective pollution abatement strategies at a European scale. Some additional benefits are connected to the implementation of diverse local policies. The effect of the North Atlantic Oscillation (NAO) was investigated. Negative NAO phases were related to additional air quality benefits, while positive phases mostly contributed to air degradation.

Cerro, J. C., V. Cerdà, & J. Pey (2015) Trends of air pollution in the Western Mediterranean Basin from a 13-year database: A research considering regional, suburban and urban environments in Mallorca (Balearic Islands), ATMOSPHERIC ENVIRONMENT 103:138-146.

Size distribution of carbonaceous aerosols at a high-altitude site on the central Tibetan Plateau (Nam Co Station, 4730 m a.s.l.)

Abstract - The chemical composition and size distribution characteristics of atmospheric aerosols have important effects on the environment, human health and climate change. In this paper, we study the size distribution of carbonaceous aerosols at the remote and pristine site, Nam Co Monitoring and Research Station for Multisphere Interactions, in the inland Tibetan Plateau (TP) based on collected size-segregated aerosols during 2012. The samples were quantified using the thermal/optical (TOR) method. The overall average concentrations of OC and EC in TSP, PM9.0, PM2.1, and PM1.0 were 4.61 g m 3 and 0.19 g m 3, 4.52 g m 3 and 0.18 g m 3, 2.72 g m 3 and 0.11 g m 3, and 2.11 g m 3 and 0.09 g m 3, respectively. Generally, the highest concentration of OC and EC in different aerosol size occurred during winter. The low level of EC indicated that direct anthropogenic disturbances in the interior of the TP still remain insignificant.

The size distributions of OC and EC concentrations presented bimodal variations. In winter, pre-monsoon, monsoon, and post-monsoon seasons, the peaks for OC were in droplet mode (0.43–0.65 m) and coarse mode (4.7–5.8 m); while in the monsoon period, the coarse mode shifted to a smaller

size bin (3.3–4.7 m). The coarse mode may be due to dust particles while the droplet mode may be due to the growth process of particles. For EC, the peaks variations in coarse mode were as same as OC, while the other peaks were complicated: the peaks during winter, pre-monsoon, and monsoon seasons exhibited in droplet mode (1.1–2.1 m, 0.65–1.1 m, and 0.43–0.65 m, respectively), and in post-monsoon period, the peak located in condensation mode. The highest peak concentrations for OC and EC occurred in winter and the pre-monsoon period, while the lowest peak values in the monsoon and post-monsoon periods, respectively. The size distribution variations may be caused by deposition, gas/particles exchange, hygroscopic growth, external mixing, and secondary organic carbon formation. OC/EC ratios in aerosols over the TP mostly exhibit high values, which emphasizes the importance of OC over this region.

Wan, X., S. Kang, Y. Wang, J. Xin, B. Liu, Y. Guo, T. Wen, G. Zhang, & Z. Cong (2015) *Size distribution of carbonaceous aerosols at a high-altitude site on the central Tibetan Plateau (Nam Co Station, 4730 m a.s.l.)*, ATMOSPHERIC RESEARCH 153:155-164.

A study of aerosol optical properties during ozone pollution episodes in 2013 over Shanghai, China

Abstract - Aerosol optical property is essential to the tropospheric ozone formation mechanism while it was rarely measured in ozone-rich environment for a specific study. With the retrieved products of the sun-photometer, a comparative investigation was conducted on aerosol optical depth (AOD), single scattering albedo (SSA) and size distribution during ozone-polluted episodes and clean background. Contrary to expectations, aerosol loading was found to be positively-correlated with ozone concentration: daily averaged AOD at 500 nm in ozone episodes (~ 0.78) displayed 2.4 times higher than that in clean days (~ 0.32). Large Ångström exponent (~ 1.51) along with heavy aerosol loading indicated a considerable impact of fine particles on optical extinction. The dynamic diurnal fluctuation of these parameters also implied a complex interaction between aerosols and photo-chemical reactions. The bimodal lognormal distribution pattern for aerosol size spectra exhibited in both ozone-polluted and clean days. The occurrence of maximum volume concentration (~ 0.28) in fine mode (radius < 0.6 m) was observed at 3 p.m. (local time), when ozone was substantially generated. Pronounced scattering feature of aerosol was reproduced in high-concentration ozone environment. SSA tended to increase continuously from morning (~ 0.91 at 440 nm) to afternoon (~ 0.99), which may be associated with secondary aerosol formation. The scattering aerosol (with moderately high aerosol loading) may favor the ozone formation through increasing solar flux in boundary layer. Utilizing the micro-pulse lidar (MPL), a more developed planet boundary layer (PBL, top height ~ 1.96 km) was discovered during ozone-polluted days than clean condition (~ 1.4 km). In episodes, the maximum extinction ratio (~ 0.5 km 1) was presented at a height of 1.2 km in the late afternoon. The humidity profile by sounding also showed the extreme value at this altitude. It suggested that optical extinction was mainly attributed to the aerosol in middle PBL, where the intense photochemical reactions and hydroscopic growth may occur.

Shi, C., S. Wang, R. Liu, R. Zhou, D. Li, W. Wang, Z. Li, T. Cheng, & B. Zhou (2015) *A study of aerosol optical properties during ozone pollution episodes in 2013 over Shanghai, China*, ATMOSPHERIC RESEARCH 153:235-249.

Secondary organic aerosol contributions to PM2.5 in Monterrey, Mexico: Temporal and seasonal variation

Abstract - Air pollution caused by fine particles is a problem of great concern in the Monterrey Metropolitan Area (MMA) which is the third largest city and the second most important industrial center in Mexico. In this study, samples of fine particulate matter emissions with an aerodynamic diameter of less than 2.5 m (PM2.5) were collected for 12-hour periods during the spring and fall of 2011 and 2012. Eighty-three samples were analyzed for organic carbon (OC) and elemental carbon (EC). The carbonaceous fraction (OC + EC) accounted for 28–55% of the PM2.5 mass. The average OC/EC ratios ranged from 7.4 to 12.6, and OC and EC concentrations were statistically significant correlated ($R2 = 0.81$, $p < 0.01$). The secondary organic aerosol (SOA) contributions were determined using two approaches: the EC tracer method based on a primary OC/EC ratio derived from a tunnel study and the minimum observed OC/EC ratio. SOAs were determined to constitute, on average, 59–87% and 32–45% of the total OC and PM2.5, respectively. The relationship between O3 and wind speed indicated that pollutant levels were influenced by transport events during the spring, while

stagnation events predominated during the fall campaigns. Statistically significant correlations were observed between OC and EC and gaseous species (CO, NOx, and SO2), indicating a contribution by combustion of fossil fuels to the carbonaceous material.

Mancilla, Y., P. Herckes, M. P. Fraser, & A. Mendoza (2015) *Secondary organic aerosol contributions to PM2.5 in Monterrey, Mexico: Temporal and seasonal variation*, ATMOSPHERIC RESEARCH 153:348-359.

Aerosol optical properties and their relationship with meteorological parameters during wintertime in Delhi, India

Abstract - In situ and columnar measurements of aerosol optical properties (AOPs) [Aerosol optical depth (AOD), Angstrom Exponent (AE), Aerosol scattering (scat) and absorption (abs) coefficients and single scattering albedo (SSA)] along with soot particles (Black carbon: BC) and fine particles (PM2.5: d   2.5) were continuously measured at an urban site in Delhi, India during winter period (December 2011 to March 2012). Average values of AOD, scat, abs, and SSA at 500 nm; and AE for the observation period were found to be 0.95   0.32, 1027.36   797.1 Mm 1, 85.95   73.2 Mm 1 and 0.93   0.03; and 0.94   0.19, respectively. Higher values of scat and abs were occurred in the month of December (1857 and 148 Mm 1) while relatively lower values of scat (585 Mm 1) and abs (44 Mm 1) were occurred in March and February respectively. SSA, however, was higher during January (0.94) and lower in March (0.89). The mass concentration of PM2.5 and BC were 195.34   157.99 and 10.11   8.83 g m 3 respectively during study period. Bimodal distributions were observed in scat and abs coefficients during 0800 and 0900 h LT (traffic rush hours) and at 2200 and 2300 h LT (low boundary layer conditions) with lower values during daytime between 1500 and 1700 h LT, respectively. The scat peak in morning may be attributed to large emissions of aerosol in the traffic rush hours and production of secondary aerosols with increasing solar radiation and temperature. During study period, the scat (mean) coefficient was 13% lower during daytime as compared to nighttime. An interesting feature was seen in monthly analysis of scat in between day and nighttime which was 18% and 22% higher in December and January in nighttime however ~ 4% lower during February and March; it is due to effect of local meteorology. The impact of meteorological parameters such as wind speed (WS), wind direction (WD), visibility (VIS) and mixed layer depths (MLDs) on AOPs along with fine and soot particles were studied. A clear negative significant correlation between atmospheric visibility with scat (0.64); abs (0.57) and PM2.5 (0.56) were observed. During foggy days (VIS   1000 m), the AOPs, fine and soot particles were substantially (~ 1.8 times) higher as compared to clean days, however, it was ~ 2.3 times higher during dense foggy days (VIS   500 m). Similarly higher (~ 2 times) AOPs and aerosol concentrations were also seen below 200 m MLDs. In addition to this, ~ 4 times higher AOPs and aerosol mass concentrations were observed when WS was below 1 m/s. In view of the above results and regression analysis, we can say that the meteorological parameters play a crucial role in enhancement of aerosols at ground level during winter period over Delhi.

Tiwari, S., G. Pandithurai, S. D. Attri, A. K. Srivastava, V. K. Soni, D. S. Bisht, V. Anil Kumar, & M. K. Srivastava (2015) *Aerosol optical properties and their relationship with meteorological parameters during wintertime in Delhi, India*, ATMOSPHERIC RESEARCH 153:465-479.

Applicability of a noise-based model to estimate in-traffic exposure to black carbon and particle number concentrations in different cultures

Abstract - Several studies show that a significant portion of daily air pollution exposure, in particular black carbon (BC), occurs during transport. In a previous work, a model for the in-traffic exposure of bicyclists to BC was proposed based on spectral evaluation of mobile noise measurements and validated with BC measurements in Ghent, Belgium. In this paper, applicability of this model in a different cultural context with a totally different traffic and mobility situation is presented. In addition, a similar modeling approach is tested for particle number (PN) concentration.

Indirectly assessing BC and PN exposure through a model based on noise measurements is advantageous because of the availability of very affordable noise monitoring devices. Our previous work showed that a model including specific spectral components of the noise that relate to engine and rolling emission and basic meteorological data, could be quite accurate. Moreover, including a

background concentration adjustment improved the model considerably. To explore whether this model could also be used in a different context, with or without tuning of the model parameters, a study was conducted in Bangalore, India. Noise measurement equipment, data storage, data processing, continent, country, measurement operators, vehicle fleet, driving behavior, biking facilities, background concentration, and meteorology are all very different from the first measurement campaign in Belgium. More than 24 h of combined in-traffic noise, BC, and PN measurements were collected. It was shown that the noise-based BC exposure model gives good predictions in Bangalore and that the same approach is also successful for PN. Cross validation of the model parameters was used to compare factors that impact exposure across study sites. A pooled model (combining the measurements of the two locations) results in a correlation of 0.84 when fitting the total trip exposure in Bangalore. Estimating particulate matter exposure with traffic noise measurements was thus shown to be a valid approach across countries and cultures.

Dekoninck, L., D. Botteldooren, L. I. Panis, S. Hankey, G. Jain, Karthik S, & J. Marshall (2015) *Applicability of a noise-based model to estimate in-traffic exposure to black carbon and particle number concentrations in different cultures*, ENVIRONMENT INTERNATIONAL 74:89-98.

Oxidative aging and cloud condensation nuclei activation of laboratory combustion soot

Abstract - Radiative forcing by aerosol particles containing black carbon (BC) may be positive or negative depending on specific atmospheric conditions. Black carbon itself absorbs solar radiation and thereby heats the surrounding environment. On the other hand, as a result of atmospheric aging, BC-containing particles may become hydrophilic due to oxidation, condensation, and/or coagulation of water-soluble material. The aged particles can act as cloud condensation nuclei (CCN) and contribute to cloud formation that may result either in cooling or heating. In this work, through a series of laboratory experiments, we investigate the transformation of soot particles from hydrophobic to hydrophilic and estimate the atmospheric residence time required for this transformation. Ethylene flame-generated soot particles were size-selected and exposed to OH radicals in a Potential Aerosol Mass flow reactor. Aging was simulated via OH exposures equivalent to atmospheric lifetimes over a range from hours to multiple days. The chemical composition of the organic coatings as a function of OH exposure was monitored with an Aerodyne Aerosol Mass Spectrometer. The CCN activity of the aged soot particles was measured as a function of OH exposure and chemical composition. Experimental measurements indicate that heterogeneous OH oxidation of initially CCN-inactive nascent soot produces CCN-active particles. Critical supersaturations at integrated OH exposures equivalent to 0.4, 2, and 10 days are 2.1%, 0.82%, and 0.40%. Corresponding values for the effective hygroscopicity parameter, image, ranged from image to image as a function of OH exposure. Condensation of hydrophilic organic or inorganic coatings (produced from oxidation of gas-phase precursors introduced to the flow reactor) on soot particles speeds up the CCN activation by a factor of 6–50 depending on the nature and thickness of the coating. The results suggest that CCN activation of atmospheric BC-containing particles is primarily due to secondary coatings.

Lambe, A. T., A. T. Ahern, J. P. Wright, D. R. Croasdale, P. Davidovits, & T. B. Onasch (2015) *Oxidative aging and cloud condensation nuclei activation of laboratory combustion soot*, Journal of Aerosol Science 79:31-39.

Chemical and optical properties of aerosols and their interrelationship in winter in the megacity Shanghai of China

Abstract - A field campaign on air quality was carried out in Shanghai in winter of 2012. The concentrations of NO, NO2, NOx, SO2, CO, and PM2.5 increased during haze formation. The average masses of SO42 , NO3 and NH4+ were 10.3, 11.7 and 6.7 g/m3 during the haze episodes, which exceeded the average (9.2, 7.9, and 3.4 g/m3) of these components in the non-haze days. The mean values for the aerosol scattering coefficient (bsp), aerosol absorption coefficient (bap) and single scattering albedo (SSA) were 288.7, 27.7 and 0.91 Mm-1, respectively. A bi-peak distribution was observed for the mass concentrations of CO, NO, NO2, and NOx. More sulfate was produced during daytime than that in the evening due to photochemical reactions. The mass concentration of NH4+ achieved a small peak at noontime. NO3 showed lower concentrations in the afternoon and higher concentrations in the early morning. There were obvious bi-peak diurnal patterns for bsp and bap as

well as SSA. bsp and bap showed a positive correlation with PM2.5 mass concentration. (NH4)2SO4, NH4NO3, organic mass, elemental carbon and coarse mass accounted for 21.7%, 19.3%, 31.0%, 9.3% and 12.3% of the total extinction coefficient during non-haze days, and 25.6%, 24.3%, 30.1%, 8.1% and 8.2% during hazy days. Organic matter was the largest contributor to light extinction. The contribution proportions of ammonium sulfate and ammonium nitrate to light extinction were significantly higher during the hazy time than during the non-haze days.

Han, T., L. Qiao, M. Zhou, Y. Qu, J. Du, X Liu, S. Lou, C. Chen, H. Wang, F. Zhang, Q. Yu, & Q. Wu (2015) Chemical and optical properties of aerosols and their interrelationship in winter in the megacity Shanghai of China, JOURNAL OF ENVIRONMENTAL SCIENCES 27:59-69.

Aerosol optical properties and radiative effects over Manora Peak in the Himalayan foothills: seasonal variability and role of transported aerosols

Abstract - The higher altitude regions of Himalayas and Tibetan Plateau are influenced by the dust and black carbon (BC) aerosols from the emissions and long-range transport from the adjoining areas. In this study, we present impacts of advection of polluted air masses of natural and anthropogenic emissions, on aerosol optical and radiative properties at Manora Peak (~ 2000 m amsl) in central Himalaya over a period of more than two years (February 2006–May 2008). We used the most updated and comprehensive data of chemical and optical properties available in one of the most climatically sensitive region, the Himalaya, to estimate atmospheric radiative forcing and heating rate. Aerosol optical depth (AOD) was found to vary from 0.04 to 0.45 with significantly higher values in summer mainly due to an increase in mineral dust and biomass burning aerosols due to transport. In contrast, single scattering albedo (SSA) varied from 0.74 to 0.88 with relatively lower values during summer, suggesting an increase in absorbing BC and mineral dust aerosols. As a result, a large positive atmospheric radiative forcing (about 28   5 Wm 2) and high values of corresponding heating rate (0.80   0.14 Kday 1) has been found during summer. During the entire observation period, radiative forcing at the top of the atmosphere varied from   2 to + 14 Wm 2 and from   3 to   50 Wm 2 at the surface whereas atmospheric forcing was in the range of 3 to 65 Wm 2 resulting in a heating rate of 0.1–1.8 Kday 1.

Srivastava, A. K., K. Ram, S. Singh, S. Kumar, & S. Tiwari (2015) Aerosol optical properties and radiative effects over Manora Peak in the Himalayan foothills: seasonal variability and role of transported aerosols, SCIENCE OF THE TOTAL ENVIRONMENT 502:287-295.

Long-range transport and regional sources of PM2.5 in Beijing based on long-term observations from 2005 to 2010

Abstract - Haze pollution in Beijing is rather deteriorated. Long-term measurement of PM2.5 from 2005 to 2010 at an urban site in Beijing showed very high concentration level with an annual average 74   55 g/m3. The contribution of regional sources is one of the most important factors; thus, transport and regional sources of PM2.5 in Beijing are investigated using the trajectory cluster and receptor models (potential source contribution function and trajectory sector analysis). The results indicated that the highest concentrations of PM2.5 (76–120 g/m3) were associated with south, southeast, and short northwest trajectories, and moderate concentrations (46–67 g/m3) with long northwest and short north trajectories, and the lowest concentrations (20–33 g/m3) with long north trajectories. During the relatively polluted periods, the probable locations of regional emission sources were mainly in the south and the west of Beijing and varied according to different seasons. Between 2005 and 2010, the annual mean contribution of 35.5% (32.8 g/m3) for PM2.5 was attributed to long-distance transportation. The transported contribution percentages from 2005 to 2010 for PM2.5 showed an increasing tendency with a linear rate of 1.2/year.

Wang, L., Z. Liu, Y. Sun, D. Ji, & Y. Wang (2015) Long-range transport and regional sources of PM2.5 in Beijing based on long-term observations from 2005 to 2010, ATMOSPHERIC RESEARCH 157:37-48.

Health impacts and economic losses assessment of the 2013 severe haze event in Beijing area

Abstract - Haze is a serious air pollution problem in China, especially in Beijing and surrounding areas, affecting visibility, public health and regional climate. In this study, the Weather Research and Forecasting-Chemistry (WRF-Chem) model was used to simulate PM2.5 (particulate matters with aerodynamic diameter 2.5 m) concentrations during the 2013 severe haze event in Beijing, and health impacts and health-related economic losses were calculated based on model results. Compared with surface monitoring data, the model results reflected pollution concentrations accurately (correlation coefficients between simulated and measured PM2.5 were 0.7, 0.4, 0.5 and 0.6 in Beijing, Tianjin, Xianghe and Xinglong stations, respectively). Health impacts assessments show that the PM2.5 concentrations in January might cause 690 (95% confidence interval (CI): (490, 890)) premature deaths, 45,350 (95% CI: (21,640, 57,860)) acute bronchitis and 23,720 (95% CI: (17,090, 29,710)) asthma cases in Beijing area. Results of the economic losses assessments suggest that the haze in January 2013 might lead to 253.8 (95% CI: (170.2, 331.2)) million US$ losses, accounting for 0.08% (95% CI: (0.05%, 0.1%)) of the total 2013 annual gross domestic product (GDP) of Beijing.

Gao, M., S. K. Guttikunda, G. R. Carmichael, Y. Wang, Z. Liu, C. O. Stanier, P. E. Saide, & M. Yu (2015) Health impacts and economic losses assessment of the 2013 severe haze event in Beijing area, SCIENCE OF THE TOTAL ENVIRONMENT *511:553-561.*

Air pollution and mortality: Effect modification by personal characteristics and specific cause of death in a case-only study

Abstract - Short-term effects of air pollution on mortality have been well documented in the literature worldwide. Less is known about which subpopulations are more vulnerable to air pollution. We conducted a case-only study in Hong Kong to examine the potential effect modification by personal characteristics and specific causes of death. Individual information of 402,184 deaths of non-external causes and daily mean concentrations of air pollution were collected from 2001 to 2011. For a 10 g/m3 increase of pollution concentration, people aged $\nabla 65$ years (compared with younger ages) had a 0.9–1.8% additional increase in mortality related to PM, NO2, and SO2. People dying from cardiorespiratory diseases (compared with other non-external causes) had a 1.6–2.3% additional increase in PM and NO2 related mortality. Other subgroups that were particularly susceptible were females and those economically inactive. Lower socioeconomic status and causes of cardiorespiratory diseases would increase the likelihood of death associated with air pollution.

Qiu, H., L. Tian, K. Ho, V. C. Pun, X. Wang, & I. T. S. Yu (2015) Air pollution and mortality: Effect modification by personal characteristics and specific cause of death in a case-only study, ENVIRONMENTAL POLLUTION *199:192-197.*

A multi-scale health impact assessment of air pollution over the 21st century

Abstract – Background: Ozone and PM2.5 are current risk factors for premature death all over the globe. In coming decades, substantial improvements in public health may be achieved by reducing air pollution. To better understand the potential of emissions policies, studies are needed that assess possible future health impacts under alternative assumptions about future emissions and climate across multiple spatial scales. Method: We used consistent climate–air-quality–health modeling framework across three geographical scales (World, Europe and Ile-de-France) to assess future (2030– 2050) health impacts of ozone and PM2.5 under two emissions scenarios (Current Legislation Emissions, CLE, and Maximum Feasible Reductions, MFR). Results: Consistently across the scales, we found more reductions in deaths under MFR scenario compared to CLE. 1.5 [95% CI: 0.4, 2.4] million CV deaths could be delayed each year in 2030 compared to 2010 under MFR scenario, 84% of which would occur in Asia, especially in China. In Europe, the benefits under MFR scenario (219 000 CV deaths) are noticeably larger than those under CLE (109 000 CV deaths). In Ile-de-France, under MFR more than 2830 annual CV deaths associated with PM2.5 changes could be delayed in 2050 compared to 2010. In Paris, ozone-related respiratory mortality should increase under both scenarios. Conclusion: Multi-scale HIAs can illustrate the difference in direct consequences of costly mitigation

policies and provide results that may help decision-makers choose between different policy alternatives at different scales.

Likhvar, V. N., M. Pascal, K. Markakis, A. Colette, D. Hauglustaine, M. Valari, Z. Klimont, S. Medina, & P. Kinney (2015) A multi-scale health impact assessment of air pollution over the 21st century, Science of The Total Environment *514:439-449.*

Respiratory hospitalizations of children and residential exposure to traffic air pollution in Jerusalem

Abstract - Although exposure to traffic-related air pollution has been reported to be associated with respiratory morbidity in children, this association has not been examined in Israel. Jerusalem is ranked among the leading Israeli cities in transport-related air pollution. This case–control study examined whether pediatric hospitalization for respiratory diseases in Jerusalem is related to residential exposure to traffic-related air pollution. Cases (n = 4844) were Jerusalem residents aged 0–14 years hospitalized for respiratory illnesses between 2000 and 2006. These were compared to children admitted electively (n = 2161) or urgently (n = 3085) for non-respiratory conditions. Individual measures of exposure included distance from residence to nearest main road, the total length of main roads, traffic volume, and bus load within buffers of 50, 150, and 300 m around each address. Cases were more likely to have any diesel buses passing within 50 m of their home (adjusted odds ratios = 1.16 and 1.10, 95% confidence intervals 1.04–1.30 and 1.01–1.20 for elective and emergency controls, respectively). Our findings indicated that older girls (5–14) and younger boys (0–4) had increased risks of respiratory hospitalization, albeit with generally widened confidence intervals due to small sample sizes. Our results add to the limited body of evidence regarding associations between diesel exhaust particles and respiratory morbidity. The findings also point to possible differential associations between traffic-related air pollution and pediatric hospitalization among boys and girls in different age groups.

Nirel, R., M. Schiff, & O. Paltiel (2015) Respiratory hospitalizations of children and residential exposure to traffic air pollution in Jerusalem, International Journal of Hygiene and Environmental Health *218:34-40.*

A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke

Abstract – Background: Climate change is likely to increase the threat of wildfires, and little is known about how wildfires affect health in exposed communities. A better understanding of the impacts of the resulting air pollution has important public health implications for the present day and the future. Method: We performed a systematic search to identify peer-reviewed scientific studies published since 1986 regarding impacts of wildfire smoke on health in exposed communities. We reviewed and synthesized the state of science of this issue including methods to estimate exposure, and identified limitations in current research. Results: We identified 61 epidemiological studies linking wildfire and human health in communities. The U.S. and Australia were the most frequently studied countries (18 studies on the U.S., 15 on Australia). Geographic scales ranged from a single small city (population about 55,000) to the entire globe. Most studies focused on areas close to fire events. Exposure was most commonly assessed with stationary air pollutant monitors (35 of 61 studies). Other methods included using satellite remote sensing and measurements from air samples collected during fires. Most studies compared risk of health outcomes between 1) periods with no fire events and periods during or after fire events, or 2) regions affected by wildfire smoke and unaffected regions. Daily pollution levels during or after wildfire in most studies exceeded U.S. EPA regulations. Levels of $PM10$, the most frequently studied pollutant, were 1.2 to 10 times higher due to wildfire smoke compared to non-fire periods and/or locations. Respiratory disease was the most frequently studied health condition, and had the most consistent results. Over 90% of these 45 studies reported that wildfire smoke was significantly associated with risk of respiratory morbidity. Conclusion: Exposure measurement is a key challenge in current literature on wildfire and human health. A limitation is the difficulty of estimating pollution specific to wildfires. New methods are needed to separate air pollution levels of wildfires from those from ambient sources, such as transportation. The majority of studies found that wildfire smoke was associated with increased risk of respiratory and cardiovascular diseases. Children, the elderly and those with underlying chronic diseases appear to be susceptible. More studies on mortality and cardiovascular morbidity are needed. Further exploration with new

methods could help ascertain the public health impacts of wildfires under climate change and guide mitigation policies.

Liu, J. C., G. Pereira, S. A. Uhl, M. A. Bravo, & M. L. Bell (2015) *A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke,* ENVIRONMENTAL RESEARCH 136:120-132.

Systematic review and meta-analysis of the adverse health effects of ambient PM2.5 and PM10 pollution in the Chinese population

Abstract – Introduction: As the largest developing country, China has some of the worst air quality in the world. Heavy smog in January 2013 led to unprecedented public concern about the health impact of exposure to particulate matter. Conducting health impact assessments of particulate matter has thus become an urgent task for public health practitioners. Combined estimates of the health effects of exposure to particulate matter from quantitative reviews could provide vital information for epidemiology-based health impact assessments, but estimates for the Chinese population are limited. Methods: On December 31, 2013, we systematically searched the PubMed, Web of Science, and China National Knowledge Infrastructure databases using as keywords names of 127 major cities in Mainland China, Hong Kong, and Taiwan. From among the 1464 articles identified, 59 studies were manually screened. Random-effects or fixed-effects models were used to combine their risk estimates, the funnel plots with Egger test were performed to evaluate the publication bias and Meta regression were run to explore the association between exposure to particulate matter with aerodynamic diameters less than 10 and 2.5 m (PM10 and PM2.5) and the resulting health effects by the Comprehensive Meta Analysis. Results: In terms of short-term effects, the combined excess risks of total non-accidental mortality, mortality due to cardiovascular disease, and mortality due to respiratory disease were 0.36% (95% confidence interval [95%CI: 0.26%, 0.46%), 0.36% (95%CI: 0.24%, 0.49%), and 0.42% (95%CI: 0.28%, 0.55%), for each 10 g/m3 increase in PM10. A 10 g/m3 increase in PM2.5 was associated with a 0.40% (95%CI: 0.22%, 0.59%) increase in total non-accidental mortality, a 0.63% (95%CI: 0.35%, 0.91%) increase in mortality due to cardiovascular disease, and a 0.75% (95%CI: 01.39%, 1.11%) increase in mortality due to respiratory disease. For constituent-specific mortality, increases of 0.40–3.11% were associated with an increase of 10 ng/m3 for nickel in PM. The summary estimate ranges of hospital utilization were 0.08% ~0.72% and –0.58% ~1.32% for a 10 g/m3 increase in PM10 and PM2.5. In terms of long-term effects, a 10 g/m3 increase of PM10 corresponded to 23–67% increase in the risk of mortality. Conclusion: Short exposures to PM10 and PM2.5 are associated with increases in mortality, but evidence of constituent-associated health effects, long-term effects and morbidity in China is still inadequate.

Lu, F., D. Xu, Y. Cheng, S. Dong, C. Guo, X. Jiang, & X. Zheng (2015) *Systematic review and meta-analysis of the adverse health effects of ambient PM2.5 and PM10 pollution in the Chinese population,* ENVIRONMENTAL RESEARCH 136:196-204.

Carbon loading in airway macrophages as a biomarker for individual exposure to particulate matter air pollution — A critical review

Abstract - Exposure to particulate matter (PM) is associated with adverse health effects, including chronic lung diseases, lung cancer and cardiovascular disease. Personal exposure varies depending on the generation of particles locally, background levels, activity patterns and meteorology. Carbon loading in airway macrophages (AM) is a novel marker to assess personal exposure to combustion-derived particles. This review summarizes the published evidence and describes the validity and reliability of this marker with a focus on the technical aspects. Carbon loading in AM is reported in nine published studies assessing personal exposure to particulate air pollution. The carbon content is quantified by image analysis and is suggested to be suited to assess cumulative exposures. While there is some variation in study technique, these studies each indicate that internal AM carbon reflects either external exposure or important health effects. However, some uncertainty remains regarding potentially confounding materials within particles, the time frame of exposures that this technique reflects, and the optimal strategy to accurately quantify AM carbon. These aspects need to be clarified or optimized before applying this technique in larger populations.

Bai, Y., R. E. Brugha, L. Jacobs, J. Grigg, T. S. Nawrot, & B. Nemery (2015) Carbon loading in airway macrophages as a biomarker for individual exposure to particulate matter air pollution — A critical review, ENVIRONMENT INTERNATIONAL 74:32-41.

Air pollution and cardiovascular disease

Abstract - An escalating body of epidemiologic and clinical research provides compelling evidence that exposure to fine particulate matter (PM) air pollution contributes to the development of cardiovascular disease (CVD) and the triggering of acute cardiac events. Three potential mediating pathways have been implicated, including "systemic spill-over," autonomic imbalance, and circulating PM constituents. Further support that the increased morbidity and mortality attributed to air pollution comes from studies demonstrating the adverse cardiovascular effects of even brief periods of exposure to secondhand smoke. Accordingly, persons with known or suspected CVD, the elderly, diabetics, pregnant women, and those with pulmonary disease should be counseled to limit leisure-time outdoor activities when air pollution is high. Recognizing the insidious and pervasive nature of air pollution, and the associated odds ratios and population attributable fractions for this widely underappreciated chemical trigger of acute cardiovascular events, may serve to maximize the potential for cardiovascular risk reduction by addressing at least a portion of the 10% to 25% incidence of coronary disease that is unexplained by traditional risk factors.

Franklin, B. A., R. Brook, & C. A. Pope III (2015) Air pollution and cardiovascular disease, CURRENT PROBLEMS IN CARDIOLOGY (In Press).

Relationship between exposure to fine particulates and ozone and reduced lung function in children

Abstract – Background: A limited number of studies have reported an association between long-term exposure to ambient air pollutants and lung function growth among children, with inconclusive results. Objectives: To assess the relationship between air pollutant exposure and lung function growth, and to examine potential sex differences in the susceptibility of lung function growth to air pollution. Methods: We conducted a two-year prospective cohort study of Taiwanese children aged 12 at baseline who were followed from October 1, 2007 to November 31, 2009. The study population comprised 2941 non-smoking children who completed pulmonary function tests at both baseline and follow-up surveys. We applied spatial modeling for individual-level exposure assessment to capture relevant exposures and also attempted to eliminate potential community-level confounding. The exposure parameters were annual averages and values calculated from 24-hourly $PM_{2.5}$ and 8-hourly ozone (O_3) concentrations, corresponding to the residential addresses over the study period. The effect estimates were presented as lung function growth deficits per interquartile range (IQR) for $PM_{2.5}$ and O_3. Results: In a multiple linear mixed effect model, adjusted for confounding, growth deficits in the forced vital capacity (FVC), forced expiration volume in 1 s (FEV1), and forced expiratory flow between the 25th and 75th percentiles of the FVC were associated with increased exposure to $PM_{2.5}$ and O_3. For example, greater exposure to $PM_{2.5}$ (IQR, 17.92 g/m3) was associated with an annual deficit in FVC growth of 75 mL in boys and 61 mL in girls (p for interaction <0.05). Similar associations were found for O_3. Conclusions: The study provides evidence that long-term exposure to $PM_{2.5}$ and O_3 may have a detrimental effect on the development of lung function in children. The estimated deficits were generally larger in boys, compared to girls.

Hwang, B., Y. Chen, Y. Lin, X. Wu, & Y. L. Lee (2015) Relationship between exposure to fine particulates and ozone and reduced lung function in children, ENVIRONMENTAL RESEARCH 137:382-390.

Megacities air pollution problems: Mexico City Metropolitan Area critical issues on the central nervous system pediatric impact

Abstract - The chronic health effects associated with sustained exposures to high concentrations of air pollutants are an important issue for millions of megacity residents and millions more living in smaller urban and rural areas. Particulate matter (PM) and ozone (O_3) concentrations close or above their respective air quality standards during the last 20 years affect 24 million people living in the Mexico City Metropolitan Area (MCMA). Herein we discuss PM and O_3 trends in MCMA and their possible association with the observed central nervous system (CNS) effects in clinically healthy children. We

argue that prenatal and postnatal sustained exposures to a natural environmental exposure chamber contribute to detrimental neural responses. The emerging picture for MCMA children shows systemic inflammation, immunodysregulation at both systemic and brain levels, oxidative stress, neuroinflammation, small blood vessel pathology, and an intrathecal inflammatory process, along with the early neuropathological hallmarks for Alzheimer and Parkinson's diseases. Exposed brains are briskly responding to their harmful environment and setting the bases for structural and volumetric changes, cognitive, olfactory, auditory and vestibular deficits and long term neurodegenerative consequences. We need to improve our understanding of the PM pediatric short and long term CNS impact through multidisciplinary research. Public health benefit can be achieved by integrating interventions that reduce fine PM levels and pediatric exposures and establishing preventative screening programs targeting pediatric populations that are most at risk. We fully expect that the health of 24 million residents is important and blocking pediatric air pollution research and hiding critical information that ought to be available to our population, health, education and social workers is not in the best interest of our children.

Calderón-Garcidueñas, L., R. J. Kulesza, R. L. Doty, A. D'Angiulli, & R. Torres-Jardón (2015) *Megacities air pollution problems: Mexico City Metropolitan Area critical issues on the central nervous system pediatric impact*, ENVIRONMENTAL RESEARCH 137:157-169.

Short-term effects of particulate matter constituents on daily hospitalizations and mortality in five South-European cities: Results from the MED-PARTICLES project

Abstract – Background: Few recent studies examined acute effects on health of individual chemical species in the particulate matter (PM) mixture, and most of them have been conducted in North America. Studies in Southern Europe are scarce. The aim of this study is to examine the relationship between particulate matter constituents and daily hospital admissions and mortality in five cities in Southern Europe. Methods: The study included five cities in Southern Europe, three cities in Spain: Barcelona (2003–2010), Madrid (2007–2008) and Huelva (2003–2010); and two cities in Italy: Rome (2005–2007) and Bologna (2011–2013). A case-crossover design was used to link cardiovascular and respiratory hospital admissions and total, cardiovascular and respiratory mortality with a pre-defined list of 16 PM10 and PM2.5 constituents. Lags 0 to 2 were examined. City-specific results were combined by random-effects meta-analysis. Results: Most of the elements studied, namely EC, SO_4^{2-}, SiO_2, Ca, Fe, Zn, Cu, Ti, Mn, V and Ni, showed increased percent changes in cardiovascular and/or respiratory hospitalizations, mainly at lags 0 and 1. The percent increase by one interquartile range (IQR) change ranged from 0.69% to 3.29%. After adjustment for total PM levels, only associations for Mn, Zn and Ni remained significant. For mortality, although positive associations were identified (Fe and Ti for total mortality; EC and Mg for cardiovascular mortality; and NO_3^- for respiratory mortality) the patterns were less clear. Conclusions: The associations found in this study reflect that several PM constituents, originating from different sources, may drive previously reported results between PM and hospital admissions in the Mediterranean area.

Basagaña, X., B. Jacquemin, A. Karanasiou, B. Ostro, X. Querol, D Agis, E. Alessandrini, J. Alguacil, B. Artiñano, M. Catrambone, J. D. de la Rosa, J. Díaz, A. Faustini, S. Ferrari, F. Forastiere, K. Katsouyanni, C. Linares, C. Perrino, A. Ranzi, I. Ricciardelli, & E. Samoli (2015) *Short-term effects of particulate matter constituents on daily hospitalizations and mortality in five South-European cities: Results from the MED-PARTICLES project*, ENVIRONMENT INTERNATIONAL 75:151-158.

Autism Spectrum Disorder and Particulate Matter Air Pollution before, during, and after Pregnancy: A Nested Case–Control Analysis within the Nurses' Health Study II Cohort

Background: Autism spectrum disorder (ASD) is a developmental disorder with increasing prevalence worldwide, yet with unclear etiology. Objective: To explore the association between maternal exposure to particulate matter (PM) air pollution and odds of ASD in her child. Methods: We conducted a nested case-control study of participants in the Nurses' Health Study II (NHS II), a prospective cohort of 116,430 US female nurses recruited in 1989, followed by biennial mailed questionnaires. Subjects were NHS II participants' children born 1990-2002 with ASD (n=245), and children without ASD (n=1522) randomly selected using frequency matching for birth years. ASD was

based on maternal report, which was validated against the Autism Diagnostic Interview-Revised in a subset. Monthly averages of PM with diameters 2.5 m (PM2.5) and 2.5-10 m (PM10-2.5) were predicted from a spatiotemporal model for the continental US and linked to residential addresses. Results: PM2.5 exposure during pregnancy was associated with increased odds of ASD, with an adjusted odds ratio (OR) for ASD per interquartile range higher PM2.5 (4.42 g/m3) of 1.57 (95% CI: 1.22, 2.03) among women with the same address before and after pregnancy (160 cases, 986 controls). Associations with PM2.5 exposure 9 months before or after the pregnancy were weaker in independent models and null when all three time periods were included, while the association with the 9 months of pregnancy remained (OR=1.63; 95% CI: 1.08-2.47). The association between ASD and PM2.5 was stronger for exposure during the third trimester (OR=1.42 per inter-quartile range increase in PM2.5, 95% CI: 1.09, 1.86) than other trimesters (ORs 1.06 and 1.00) when mutually adjusted. There was little association between PM10-2.5 and ASD. Conclusions: Higher maternal exposure to PM2.5 during pregnancy, in particular the third trimester, was associated with greater odds of her child having ASD.

Raz, R., A. L. Roberts, K. Lyall, J. E. Hart, A. C. Just, F. Laden, & M. G. Weisskopf (2015) Autism Spectrum Disorder and Particulate Matter Air Pollution before, during, and after Pregnancy: A Nested Case-Control Analysis within the Nurses' Health Study II Cohort, ENVIRON HEALTH PERSPECT.

Pedestrian exposure to near-roadway PM2.5 in mixed-use urban corridors: A case study of Omaha, Nebraska

Abstract - Compact, mixed-use, and pedestrian-oriented urban developments may offer numerous environmental and health benefits, yet they may also facilitate pedestrian exposure to air pollution within the near-roadway environment. This research examines ambient concentrations of fine particulate matter (PM2.5) across six sites situated within central Omaha, Nebraska, a mid-sized metropolitan area located in the Midwest US. The sites ranged from a low-density, strip-mall development to moderate-density entertainment, commercial, and retail districts with varying degrees of horizontal and vertical mixed-use. Tracing approximately two kilometer routes along the sidewalk, factors affecting average and peak PM2.5 concentrations at each site were identified using a mobile data cart capable of simultaneously recording video and sampling PM2.5. In general, sidewalk PM2.5 concentrations, averaged for each outing, were similar to "background" values obtained at a nearby fixed monitoring station (FMS). The results of a linear regression analysis suggest that 56% of the variability in sidewalk PM2.5 were attributable to background concentrations. Short-duration peak concentrations of up to 360 g m 3 were associated primarily with vehicle tailpipe emissions and tobacco smoke. At four of the six study sites, pedestrian volume was higher on days and times when PM2.5 concentrations were comparatively low. Implications for policy and planning are discussed.

Bereitschaft, B. (2015) Pedestrian exposure to near-roadway PM2.5 in mixed-use urban corridors: A case study of Omaha, Nebraska, SUSTAINABLE CITIES AND SOCIETY 15:64-74.

Lung burden and deposition distribution of inhaled atmospheric urban ultrafine particles as the first step in their health risk assessment

Abstract - Realistic median particle number size distributions were derived by a differential mobility particle sizer in a diameter range of 6–1000 nm for near-city background, city centre, street canyon and road tunnel environments in Budapest. Deposition of inhaled particles within airway generations of an adult woman was determined by a stochastic lung deposition model for sleeping, sitting, light and heavy exercise breathing conditions. Deposition fractions in the respiratory tract were considerable and constant for all physical activities with a mean of 56%. Mean deposition fraction in the extra-thoracic region averaged for the urban environments was decreasing monotonically from 26% for sleeping to 9.4% for heavy exercise. The mean deposition fractions in the tracheobronchial region were constant for the physical activities and urban environments with an overall mean of 12.5%, while the mean deposition fraction in the acinar region averaged for the urban locations increased monotonically with physical activity from 14.7% for sleeping to 34% for heavy exercise. The largest contribution of the acinar deposition to the lung deposition was 75%. The deposition rates in the lung were larger than in the extra-thoracic region, and the deposition rate in the lung was

increasingly realised in the AC region by physical activity. It was the extra-thoracic region that received the largest surface density deposition rates; its loading was higher by 3 orders of magnitude than for the lung. Deposition fractions in the airway generations exhibited a distinct peak in the acinar region. The maximum of the curves was shifted to peripheral airway generations with physical activity. The shapes of the surface density deposition rate curves were completely different from those for the deposition rates, indicating that the first few airway generations received the highest surface loading in the lung.

Salma, I., P. Füri, Z. Németh, I. Balásházy, W. Hofmann, & Á. Farkas (2015) *Lung burden and deposition distribution of inhaled atmospheric urban ultrafine particles as the first step in their health risk assessment*, ATMOSPHERIC ENVIRONMENT 104:39-49.

Sensitivity of population smoke exposure to fire locations in Equatorial Asia

Abstract - High smoke concentrations in Equatorial Asia, primarily from land conversion to oil palm plantations, affect a densely populated region and represent a serious but poorly quantified air quality concern. Continued expansion of the oil palm industry is expected but the resulting population exposure to smoke is highly dependent on where this expansion takes place. We use the adjoint of the GEOS-Chem chemical transport model to map the sensitivity of smoke concentrations in major Equatorial Asian cities, and for the population-weighted region, to the locations of the fires. We find that fires in southern Sumatra are particularly detrimental, and that a land management policy protecting peatswamp forests in Southeast Sumatra would be of great air quality benefit. Our adjoint sensitivities can be used to immediately infer population exposure to smoke for any future fire emission scenario.

Kim, P. S., D. J. Jacob, L. J. Mickley, S. N. Koplitz, M. E. Marlier, R. S. DeFries, S. S. Myers, B. N. Chew, & Y. H. Mao (2015) *Sensitivity of population smoke exposure to fire locations in Equatorial Asia*, ATMOSPHERIC ENVIRONMENT 102:11-17.

AGRICULTURE

Implications of leading crop production practices on environmental quality and human health

Abstract - Globally, much weight is currently being placed on agriculture to provide food for the growing population as well as feedstock for the bioenergy industry. Unfortunately, the intensification of agricultural operations to satisfy these growing needs has been associated with a number of environmental and human health risks. A review of publications on the subject was conducted and emphasis was placed on articles focusing on agriculture, environment, and public health as well as their interactions. Supporting information was also gathered from publications of various agricultural and environmental agencies. Agricultural practices with potential negative implications on the environment and human health were identified broadly as: (a) utilization of biosolids and animal manures, (b) use of agricultural chemicals, (c) management of post-harvest residue, (d) irrigation, and (e) tillage operations. Soil, water, and air contamination by nutrients, heavy metals, pathogens, and pesticides, as well as air contamination by particulate matters, noxious gases, and pathogens were among the leading environmental impacts. Some of the human-health impacts identified included neurological and reproductive defects, cardiovascular risks, cancers and other diseases (of kidney, liver, lung, and skin), skin allergies, gastroenteritis, and methemoglobinemia. Continual awareness on the impacts of the reviewed agricultural practices on environmental quality and human health and the implementation of experimentally-backed best management practices in agricultural systems remain indispensable.

Udeigwe, T. K., J. M. Teboh, P. N. Eze, M. H. Stietiya, V. Kumar, J. Hendrix, H. J. Mascagni Jr., T. Ying, & T. Kandakji (2015) *Implications of leading crop production practices on environmental quality and human health*, JOURNAL OF ENVIRONMENTAL MANAGEMENT 151:267-279.

A field application of a personal sensor for ultrafine particle exposure in children

Abstract – Background: Ultrafine particles (UFPs) have been associated with adverse health outcomes in children, but studies are often limited by surrogate estimates of exposure. Accurately characterizing children's personal exposure to UFP is difficult due to the high spatiotemporal variability of UFP and children's time–activity patterns. Objective: The objectives of this study were to conduct a field test of a personal sensor for UFP (PUFP) by measuring UFP exposure among children and assess the sensor's capabilities and limitations. Methods: Children wore the sensor at school, during transit periods between school and home, and in their home for 2–4 h on 2 consecutive days and provided feedback regarding their experience with the sensor. The PUFP sensor recorded UFP number concentration at one second intervals and recorded GPS location allowing for comparisons of UFP exposure at homes, schools, and during transit. A mixed-effects linear model was used to compare the effect of microenvironment on personal UFP measurements. Results: The overall total median personal exposure to UFP was 12,900 particles/cm3 (p/cm3). Median UFP exposure at homes, schools and during transit was 17,800, 11,900, and 13,600 p/cm3, respectively. Results of the mixed-effects model found that riding in a car and walking were significantly associated with 1.36 (95% CI 1.33–1.39) and 2.51 (95% CI 2.44–2.57) times higher UFP concentrations compared to the home. Conclusions: The PUFP sensor can measure near real-time exposure to UFP with high spatiotemporal resolution. Children's exposure to UFP varies by location, with increased exposure during transit to and from school.

Personal exposure monitoring of PM2.5 in indoor and outdoor microenvironments

Abstract - Adverse health effects from exposure to air pollution are a global challenge and of widespread concern. Recent high ambient concentration episodes of air pollutants in European cities highlighted the dynamic nature of human exposure and the gaps in data and knowledge about exposure patterns. In order to support health impact assessment it is essential to develop a better understanding of individual exposure pathways in people's everyday lives by taking account of all environments in which people spend time. Here we describe the development, validation and results of an exposure method applied in a study conducted in Scotland. A low-cost particle counter based on light-scattering technology — the Dylos 1700 was used. Its performance was validated in comparison with equivalent instruments (TEOM-FDMS) at two national monitoring network sites (R2 = 0.9 at a rural background site, R2 = 0.7 at an urban background site). This validation also provided two functions to convert measured PNCs into calculated particle mass concentrations for direct comparison of concentrations with equivalent monitoring instruments and air quality limit values. This study also used contextual and time-based activity data to define six microenvironments (MEs) to assess everyday exposure of individuals to short-term PM2.5 concentrations. The Dylos was combined with a GPS receiver to track movement and exposure of individuals across the MEs. Seventeen volunteers collected 35 profiles. Profiles may have a different overall duration and structure with respect to times spent in different MEs and activities undertaken. Results indicate that due to the substantial variability across and between MEs, it is essential to measure near-complete exposure pathways to allow for a comprehensive assessment of the exposure risk a person encounters on a daily basis. Taking into account the information gained through personal exposure measurements, this work demonstrates the added value of data generated by the application of low-cost monitors.

Assessing risks to adults and preschool children posed by PM2.5-bound polycyclic aromatic hydrocarbons (PAHs) during a biomass burning episode in Northern Thailand

Abstract - To investigate the potential cancer risk resulting from biomass burning, polycyclic aromatic hydrocarbons (PAHs) bound to fine particles (PM2.5) were assessed in nine administrative northern provinces (NNP) of Thailand, before (N-I) and after (N-II) a haze episode. The average values of 3,4-

ring PAHs and B[a]PEquivalent concentrations in world urban cities were significantly (p < 0.05) much higher than those in samples collected from northern provinces during both sampling periods. Application of diagnostic binary ratios of PAHs underlined the predominant contribution of vehicular exhaust to PM2.5-bound PAH levels in NNP areas, even in the middle of the agricultural waste burning period. The proximity of N-I and N-II values in three-dimensional (3D) principal component analysis (PCA) plots also supports this conclusion. Although the excess cancer risk in NNP areas is much lower than those of other urban area and industrialized cities, there are nevertheless some concerns relating to adverse health impacts on preschool children due to non-dietary exposure to PAHs in home environments.

Pongpiachan, S., D. Tipmanee, C. Khumsup, I. Kittikoon, & P. Hirunyatrakul (2015) Assessing risks to adults and preschool children posed by PM2.5-bound polycyclic aromatic hydrocarbons (PAHs) during a biomass burning episode in Northern Thailand, SCIENCE OF THE TOTAL ENVIRONMENT 508:435-444.

BIOMASS BURNING & COOKING AND HEATING

Indoor particulate matter in rural, wood stove heated homes

Abstract - Ambient particulate matter (PM) exposures have adverse impacts on public health, but research evaluating indoor PM concentrations in rural homes in the United States using wood as fuel for heating is limited. Our objectives were to characterize indoor PM mass and particle number concentrations (PNCs), quantify infiltration of outdoor PM into the indoor environment, and investigate potential predictors of concentrations and infiltration in 96 homes in the northwestern US and Alaska using wood stoves as the primary source of heating. During two forty-eight hour sampling periods during the pre-intervention winter of a randomized trial, we assessed PM mass (<2.5 m) and PNCs (particles/cm3) in six size fractions (0.30–0.49, 0.50–0.99, 1.00–2.49, 2.5–5.0, 5.0–10.0, 10.0+ m). Daily mean (sd) PM2.5 concentrations were 28.8 (28.5) g/m3 during the first sampling period and 29.1 (30.1) g/m3 during the second period. In repeated measures analyses, household income was inversely associated with PM2.5 and smaller size fraction PNCs, in particular. Time of day was a significant predictor of indoor and outdoor PM2.5 concentrations, and infiltration efficiency was relatively low (Finf (sd)=0.27 (0.20)). Our findings demonstrate relatively high mean PM concentrations in these wood burning homes and suggest potential targets for interventions for improving indoor air quality and health in rural settings.

Semmens, E. O., C. W. Noonan, R. W. Allen, E. C. Weiler, & T. J. Ward (2015) Indoor particulate matter in rural, wood stove heated homes, ENVIRONMENTAL RESEARCH 138:93-100.

The variability of biomass burning and its influence on regional aerosol properties during the wheat harvest season in North China

Abstract - The spatial–temporal variation of biomass burning in June during the wheat harvest season in the North China (32–41 N, 111–120 E) and its influence on the regional aerosol optical depth (AOD) and the chemical compositions of size-segregated aerosols in the urban environment were investigated to evaluate the effectiveness of the burn ban policy and the influence on regional pollution. Fire events that occurred in early and middle June accounted for approximately 89% of the events during the month, and fire points located in mid-eastern China (32.5–35.5 N, 114–120 E) comprised 71%. The occurrences exhibit oscillatory changes with a minimum in 2008 (during the Beijing Olympics) and a peak and explosive growth in 2012. Under high relative humidity and south winds, fire emissions from straw burning combined with high urban/industrial emissions to produce intensive regional haze pollution in the North Plain. The formation of secondary inorganic particles was intensified due to the interactions of smoke plumes and urban/industrial pollutants in an urban environment. Higher concentrations and percentages (79%) of sulfate, nitrate, ammonium, and organic carbon in the fine particles under high relative humidity conditions contributed to a deteriorated

urban visibility. Therefore, stronger management and a comprehensive ban on wheat straw burning in June are urgently needed, especially during years when the south wind is dominant.

Wang, L., J. Xin, X. Li, & Y. Wang (2015) *The variability of biomass burning and its influence on regional aerosol properties during the wheat harvest season in North China*, ATMOSPHERIC RESEARCH 157:153-163.

Biomass cookstoves: A review of technical aspects

Abstract - Improving the thermal as well as emissions performance of biomass cookstoves has been of interest to researchers for a long time. Despite there being a vast literature on the subject, several technical issues remain unresolved with a variety of data and opinions being presented. The present article aims at bringing together literature spanning over three decades that addresses technical aspects of biomass stoves, i.e., their design, analysis and testing. Literature on various design principles, features which determine the stove performance and different methods of performance prediction have been reviewed. Different cookstove testing protocols have been compared and various issues related to cookstove testing are critically discussed. The results of laboratory and field studies on cookstoves by various researchers are presented. Literature on health impact of cookstoves, their dissemination and adoption has also been included. The focus has been on critically analyzing the findings presented by various researchers over the past 3–4 decades in the backdrop of the advancement of the state of knowledge in the area. Wherever conflicting findings were encountered, efforts have been made to reconcile the same using the understanding of the fundamental phenomena.

Sutar, K. B., S. Kohli, M. R. Ravi, & A. Ray (2015) *Biomass cookstoves: A review of technical aspects*, RENEWABLE AND SUSTAINABLE ENERGY REVIEWS 41:1128-1166.

Heating and cooling energy trends and drivers in buildings

Abstract - The purpose of this paper is to provide a source of information on thermal energy use in buildings, its drivers, and their past, present and future trends on a global and regional basis. Energy use in buildings forms a large part of global and regional energy demand. The importance of heating and cooling in total building energy use is very diverse with this share varying between 18% and 73%. Biomass is still far the dominant fuel when a global picture is considered; the role of electricity is substantially growing, and the direct use of coal is disappearing from this sector, largely replaced by electricity and natural gas in the most developed regions. This paper identifies the different drivers of heating and cooling energy demand, and decomposes this energy demand into key drivers based on a Kaya identity approach: number of households, persons per household, floor space per capita and specific energy consumption for residential heating and cooling; and GDP, floor space per GDP, and specific energy consumption for commercial buildings. This paper also reviews the trends in the development of these drivers for the present, future – and for which data were available, for the past – in 11 world regions as well as globally. Results show that in a business-as-usual scenario, total residential heating and cooling energy use is expected to more or less stagnate, or slightly decrease, in the developed parts of the world. In contrast, commercial heating and cooling energy use will grow in each world region. Finally, the results show that per capita total final residential building energy use has been stagnating in the vast majority of world regions for the past three decades, despite the very significant increases in energy service levels in each of these regions.

Ürge-Vorsatz, D., L. F. Cabeza, S. Serrano, C. Barreneche, & K. Petrichenko (2015) *Heating and cooling energy trends and drivers in buildings*, RENEWABLE AND SUSTAINABLE ENERGY REVIEWS 41:85-98.

A quantitative model of cookstove variability and field performance: Implications for sample size

Abstract - Many cookstove studies conducted in the field fail to measure meaningful differences between different stove technologies. Although meaningful differences do not always exist, significant differences are often missed because of low statistical power. A numerical model has been developed to determine the minimum sample size necessary to ensure that cookstove field studies are well-designed, efficient, and have adequate statistical power to characterize the concentrations of pollutants inside homes. The numerical model uses a Monte Carlo prediction method to generate probabilistic distributions of indoor pollutant concentrations. The model is based on a series of user

inputs, including emissions rate, home size, air-exchange rate, fuel-moisture content, and measurement error. Application of this model to an example situation showed that, even under optimistic measurement conditions, a substantially high number of test replicates would be required. This approach should allow organizations to select appropriate sample sizes to test cookstoves in the field and to identify factors that contribute to variability among tests.

L'Orange, C., D. Leith, J. Volckens, & M. DeFoort (2015) *A quantitative model of cookstove variability and field performance: Implications for sample size,* BIOMASS AND BIOENERGY 72:233-241.

Influence of springtime biomass burning in South Asia on regional ozone (O3): A model based case study

Abstract - In this study, for the first time, the influence of springtime (MAM) biomass burning in South Asia on regional ozone (O3) distribution has been evaluated using a regional chemical transport model (WRF-Chem) and the Fire Inventory from NCAR (FINNv1). Model results are compared with satellite retrievals of tropospheric column amounts of carbon monoxide (CO) from MOPITT and nitrogen dioxide (NO2) from OMI. With daily varying emissions, the model captures reasonably well the satellite-derived temporal variations in CO and NO2 (index of agreement (R) for CO is 0.83 and for NO2 is 0.76), indicating the effectiveness of the model in estimating the overall fire impact on a regional scale. Simulated tropospheric NO2 concentration shows better agreement with the magnitude of observed NO2 when FINNv1 NOx emissions are reduced by a factor of 2.2 over the model domain. A clear increase in CO and NO2 levels over Burma (35–60%), Central India (15–30%), the Indo-Gangetic (15–25%) region and the Bay of Bengal (15–40%) are simulated with fire emissions. The model results are also used to quantify the net O3 production from fires. Calculated O3 productions are up to 4 ppb h 1 over inland and up to 0.1 ppb h 1 over marine regions respectively. Our model-based analysis yields average enhancement ratios O3/ CO of 0.12 ppbv/ppbv and a total O3 production of about 3.5 Tg from South Asia during the spring season. The findings demonstrate that the springtime fire emissions in South Asia have a noticeable impact on the O3 in this region.

Jena, C., S. D. Ghude, G. G. Pfister, D. M. Chate, R. Kumar, G. Beig, D. E. Surendran, S. Fadnavis, & D. M. Lal (2015) *Influence of springtime biomass burning in South Asia on regional ozone (O3): A model based case study,* ATMOSPHERIC ENVIRONMENT 100:37-47.

How You Count Carbon Matters: Implications of Differing Cookstove Carbon Credit Methodologies for Climate and Development Cobenefits

Abstract - The opportunity to apply for carbon credits for cookstove projects creates a source of funding that can be leveraged to promote the "win-win" environmental and development benefits of improved cookstoves. Yet, as in most environment-development efforts, unacknowledged trade-offs exist under the all-encompassing "win-win" claims. This study therefore compares different scenarios for calculating cookstove carbon credits, including comparing different types of stoves using different fuels, different methodologies and theoretical scenarios to account for a range of climate-relevant emissions. The results of the study highlight the following: 1) impacts of different assumptions made within carbon credit methodologies, 2) discussion around potential trade-offs in such projects, and 3) considerations needed to truly promote sustainable development. The Gold Standard methodology was more comprehensive in its accounting and generally calculated more carbon credits per scenario than the Clean Development Mechanism methodology. Including black carbon in calculations would be more reflective of climate relevant stove emissions and greatly increase the number of credits calculated. As health and other development benefits are not inherently included in carbon credit calculations, to achieve "win-win" outcomes, deliberate decisions about project design need to be made to ensure objectives are met and not simply assumed.

Freeman, O. E. & H. Zerriffi (2015) *How You Count Carbon Matters: Implications of Differing Cookstove Carbon Credit Methodologies for Climate and Development Cobenefits,* ENVIRON. SCI. TECHNOL. 48:14112 14120.

Biomass burning dominates brown carbon absorption in the rural southeastern United States

Abstract – Brown carbon aerosol consists of light-absorbing organic particulate matter with wavelength-dependent absorption. Aerosol optical extinction, absorption, size distributions, and

chemical composition were measured in rural Alabama during summer 2013. The field site was well located to examine sources of brown carbon aerosol, with influence by high biogenic organic aerosol concentrations, pollution from two nearby cities, and biomass burning aerosol. We report the optical closure between measured dry aerosol extinction at 365 nm and calculated extinction from composition and size distribution, showing agreement within experiment uncertainties. We find that aerosol optical extinction is dominated by scattering, with single-scattering albedo values of 0.94   0.02. Black carbon aerosol accounts for 91   9% of the total carbonaceous aerosol absorption at 365 nm, while organic aerosol accounts for 9   9%. The majority of brown carbon aerosol mass is associated with biomass burning, with smaller contributions from biogenically derived secondary organic aerosol.

Washenfelder, R. A., A. R. Attwood, C. A. Brock, H. Guo, L. Xu, R. J. Weber, N. L. Ng, H. M. Allen, B. R. Ayres, K. Baumann, R. C. Cohen, D. C. Draper, K. C. Duffey, E. Edgerton, J. L. Fry, W. W. Hu, J. L. Jimenez, B. B. Palm, P. Romer, E. A. Stone, P. J. Wooldridge, & S. S. Brown (2015) Biomass burning dominates brown carbon absorption in the rural southeastern United States, GEOPHYSICAL RESEARCH LETTERS (Early View).

Size-dependent wet removal of black carbon in Canadian biomass burning plumes

Abstract - Wet deposition is the dominant mechanism for removing black carbon (BC) from the atmosphere and is key in determining its atmospheric lifetime, vertical gradient and global transport. Despite the importance of BC in the climate system, especially in terms of its ability to modulate the radiative energy budget, there are few quantitative case studies of wet removal in ambient environments. We present a case study of BC wet removal by examining aerosol size distributions and BC coating properties sampled in three Canadian boreal biomass burning plumes, one of which passed through a precipitating cloud. This depleted the majority of the plume's BC mass, and the largest and most coated BC containing particles were found to be preferentially removed, suggesting that nucleation scavenging was likely the dominant mechanism. Calculated single-scattering albedo (SSA) showed little variation, as a large number of non-BC particles were also present in the precipitation-affected plume. The remaining BC cores were smaller than those observed in previous studies of BC in post-precipitation outflow over Asia, possibly due to the thick coating by hydrophilic compounds associated with the Canadian biomass burning particles. This study provides measurements of BC size, mixing state and removal efficiency to constrain model parameterisations of BC wet removal in biomass burning regions, which will help to reduce uncertainty in radiative forcing calculations.

Taylor, J. W., J. D. Allan, G. Allen, H. Coe, P. I. Williams, M. J. Flynn, M. Le Breton, J. B. A. Muller, C. J. Percival, D. Oram, G. Forster, J. D. Lee, A. R. Rickard, M. Parrington, & P. I. Palmer (2014) Size-dependent wet removal of black carbon in Canadian biomass burning plumes, ATMOS. CHEM. PHYS. 14:13755–13771.

Organic aerosol emission ratios from the laboratory combustion of biomass fuels

Abstract - Organic aerosol (OA) emission ratios (ER) have been characterized for 67 burns during the second Fire Laboratory at Missoula Experiment. These fires involved 19 different species representing 6 major fuels, each of which forms an important contribution to the U.S. biomass burning inventory. Average normalized OA/ CO ratios show a high degree of variability, both between and within different fuel types and species, typically exceeding differen-ces between separate plumes in ambient measurements. This variability is strongly influenced by highly contrasting OA levels between burns and the increased partitioning of semivolatile organic compounds to the particle phase at high OA concentrations. No correlation across all fires was observed between OA/ CO and modified combustion efficiency (MCE), which acts as an indicator of the proportional contributions of flaming and smoldering combustion phases throughout each burn. However, a negative correlation exists with MCE for some coniferous species, most notably Douglas fir, for which there is also an influence from fuel moisture content. Changes in fire efficiency were also shown to dramatically alter emissions for fires with very similar initial conditions. Although the relationship with MCE is variable between species, there is greater consistency with the level of oxygenation in OA. The ratio of the m/z 44 fragment to total OA mass concentration (f44) as measured by aerosol mass spectrometer provides an indication of oxygenation as influenced by combustion processes at source, with OA/ CO decreasing

with increasing f44 for all fuel types. Inconsistencies in the magnitude of the effects associated with each potential influence on OA/CO emphasize the lack of a single dominant control on fire emissions, and a dependency on both fuel properties and combustion conditions.

Jolleys, M. D., H. Coe, G. McFiggans, G. R. McMeeking, T. Lee, S. M. Kreidenweis, J. L. Collett Jr., & A. P. Sullivan (2014) *Organic aerosol emission ratios from the laboratory combustion of biomass fuels*, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(22):12,850–12,871.

Yak dung combustion aerosols in the Tibetan Plateau: Chemical characteristics and influence on the local atmospheric environment

Abstract - The study of the source areas of atmospheric pollutants in the Tibetan Plateau (TP) – one of the most remote regions in the world – has raised a great deal of concern. It is generally considered that the majority of pollutants in this region are transported from outside the TP. This research investigated the water soluble elements and carbonaceous matter from aerosols emitted from yak dung combustion by local residents and re-analyzed previous OC and BC data at Nam Co — a remote area of the TP. The compositions of the water soluble elements of the studied aerosols were similar to those in precipitation and snow samples of the region under investigation. Some heavy metal elements (e.g. Cd and As) even had higher enrichment factor (EF) values (1793 and 2355, respectively) compared to those in precipitation and snow samples, implying that previously reported high EF values for precipitation and snow did not completely reflect the long-range transported pollutants from outside the TP. Accordingly, the contributions of local sources needed to be considered. Organic carbon (OC) and black carbon (BC) accounted for 55.2% and 3.63% of the studied aerosol, respectively. The OC/BC ratio of the studied aerosols was close to the corresponding value for the outdoor aerosols, further indicating the influence of local sources on the atmosphere of Nam Co. It was proposed that air masses from South Asia cause high BC concentrations in the Nam Co region. It was, however, discovered that air masses from the TP itself also induce high BC concentrations, suggesting that not all the BC of Nam Co was transported from South Asia. Therefore, it is proposed that pollutants of atmospheric aerosols of the Nam Co region were derived from a variety of sources from both the TP and outside. In other words, the influence of yak dung burning by local residents on the atmosphere of the TP cannot be overlooked. Correspondingly, long-range transported pollutants can penetrate into the inland TP only when intensified pollution events occur in South Asia.

Chen, P., S. Kang, J. Bai, M. Sillanpää, & C. Li (2015) *Yak dung combustion aerosols in the Tibetan Plateau: Chemical characteristics and influence on the local atmospheric environment*, ATMOSPHERIC RESEARCH 156:58-66.

Source apportionment of air pollution exposures of rural Chinese women cooking with biomass fuels

Abstract - Particulate matter (PM) from different sources may differentially affect human health. Few studies have assessed the main sources of personal exposure to PM and their contributions among residents of developing countries, where pollution sources differ from those in higher-income settings. 116 daily (24-h) personal PM2.5 exposure samples were collected among 81 women cooking with biomass fuels in two villages in rural Yunnan, China. The PM samples were analyzed for mass and chemical composition, including water-soluble organic carbon (WSOC), black carbon (BC), and molecular markers. We found black carbon, n-alkanes and levoglucosan dominated the most abundant fractions of the total measured species and average personal PM2.5 exposure was higher in winter than that in summer in both villages. The composition data were then analyzed using a positive matrix factorization (PMF) receptor model to identify the main PM emission sources contributing to women's exposures and to assess their spatial (between villages) and seasonal variation in our study setting. The 6-factor solution provided reasonably stable profiles and was selected for further analysis. Our results show that rural Chinese women cooking with biomass fuels are exposed to a variety of sources. The identified factors include wood combustion (41.1%), a cooking source (35.6%), a mobile source (12.6%), plant waxes (6.7%), pyrolysis combustion (3.0%), and secondary organic aerosols (SOA; 1.0%). The mean source contributions of the mobile source, cooking source, and wood combustion factor to PM2.5 exposure were significantly different between women living in the two study villages, whereas the mean SOA, wood combustion, and plant waxes

factors differed seasonally. There was no relationship between source contributions and questionnaire-based measurements of source-specific exposures, implying that the impacts of source contributions on exposure are affected by complex spatial, temporal and behavioral patterns that are difficult to quantify using questionnaire-based measurements. Epidemiologic studies, health risk assessments, and intervention programs would benefit from a better understanding of the sources impacting PM exposure among populations in developing countries.

Huang, W., J. Baumgartner, Y. Zhang, Y. Wang, & J. J. Schauer (2015) *Source apportionment of air pollution exposures of rural Chinese women cooking with biomass fuels*, ATMOSPHERIC ENVIRONMENT 104:79-87.

Emission of carbon monoxide, total hydrocarbons and particulate matter during wood combustion in a stove operating under distinct conditions

Abstract - Wood combustion experiments were carried out to determine the effect of ignition technique, biomass load and cleavage, as well as secondary air supply, on carbon monoxide (CO), total hydrocarbon (THC), particulate matter (PM10) and particle number emissions from a woodstove. Wood from two typical tree species in the Iberian Peninsula was selected: pine (Pinus pinaster) and beech (Fagus sylvatica). The highest CO and total hydrocarbon emission factors (EFs) were observed, respectively, for pine and beech, for high and low fuel loads. The highest PM10 EF was recorded for the operation with low loads for both woods. Secondary air supply produced the lowest PM10 emission factors. The top ignition can decrease the PM10 EF to less than half when compared with the common technique of lighting from the bottom. The lowest particle number emission factors were observed when operating with high loads of split beech logs and when using secondary air supply during the combustion of pine. Regarding particle number distributions, the highest geometric mean diameter (Dg), for both woods, were observed when operating with high loads (with split and non-split wood).

Vicente, E. D., M. A. Duarte, A. I. Calvo, T. F. Nunes, L. Tarelho, & C. A. Alves (2015) *Emission of carbon monoxide, total hydrocarbons and particulate matter during wood combustion in a stove operating under distinct conditions*, FUEL PROCESSING TECHNOLOGY 131:182-192.

Ash behaviour and emission formation in a small-scale reciprocating-grate combustion reactor operated with wood chips, reed canary grass and barley straw

Abstract - The emissions and ash behaviour during combustion of wood chips, or co-combustion of two solid agricultural fuels (reed canary grass and barley straw) with wood chips, were studied. In addition, the sensitivity of the results towards different air-staging conditions was investigated using pure wood chips. The experiments were carried out in a 40-kW combustion reactor equipped with a reciprocating-grate burner. The addition of the reed canary grass to the wood chips increased only slightly the emission of fine particles (PM1), nitrogen oxides (NOX) and sulphur dioxide (SO2); while carbon monoxide (CO), hydrogen chloride (HCl), organic carbon (OC), elemental carbon (EC) and the geometric diameter (GMD) of the particles either decreased or remained unchanged. However, the number of particles emitted increased 2-fold in the reed canary grass combustion compared to the pure wood chips. In contrast, the addition of straw to wood chips substantially increased the emissions of PM1, CO, EC, SO2 and HCl. The straw-originating particles were mostly crystalline KCl, and their number emission was clearly reduced, but their size was larger compared to the case with pure wood chips. The distribution of the combustion air had only a very minor influence on the release of the major ash species, whereas the effect was significant for the release of specific trace metals and the products of incomplete combustion. Finally, the partitioning of ash-forming elements with various fuels was evaluated based on chemical analyses of the fuel, bottom ash and fine fly ash fractions.

Kortelainen, M., J. Jokiniemi, I. Nuutinen, T. Torvela, H. Lamberg, T. Karhunen, J. Tissari, & O. Sippula (2015) *Ash behaviour and emission formation in a small-scale reciprocating-grate combustion reactor operated with wood chips, reed canary grass and barley straw*, FUEL 143:80-88.

Female Labor Force Participation and Household Dependence on Biomass Energy: Evidence from National Longitudinal Data

Abstract – Summary: Air pollution from household biomass combustion is an important cause of poor health in developing countries. This study employs national-level longitudinal data for up to 175 countries during 1990–2010 and finds that female labor force participation is associated with reductions in household biomass energy use. Consistent with the "fuel stacking" model, higher incomes are linked to use of other types of energy by households, but not significantly associated with reductions in use of biomass energy. The results highlight the multifaceted nature of household energy transitions and suggest an avenue by which female empowerment can lead to improved health outcomes.

Burke, P. J., & G. Dundas (2015) Female Labor Force Participation and Household Dependence on Biomass Energy: Evidence from National Longitudinal Data, WORLD DEVELOPMENT 67:424-437.

Impacts of biomass-burning on aerosol properties of a severe haze event over Shanghai

Abstract - Anthropogenic aerosols have significant impacts on the environment and human health in the Yangtze River Delta region, one of the most densely populated regions in the world. A biomass-burning plume swept across this area (Shanghai) in May 2009, leading to changes in the physical and optical properties of aerosols, which were investigated using ground-based remote sensing and in situ measurements via comparisons with dust pollution and background conditions. Experiments show that the biomass-burning plume led to an increase in the average aerosol optical depth (AOD) at 500 nm from 0.73 to 1.00 (37% higher), an absorption Angstrom exponent (AAE) of 1.48, and an increase in the Angstrom exponent ( ) up to 1.53. Furthermore, local dust aerosols derived from road dust and/or construction dust also led to higher values of AOD (2.68) and AAE (2.16), and a daily average value of of 1.05. For the biomass-burning plume, the aerosol particles exhibited significant variations in short-wavelength spectra. The single scattering albedo at 670 nm decreased remarkably under the influence of the biomass-burning plume, indicating the significant absorptive ability of the biomass-burning pollution and higher ratio of absorption aerosols within the plume. Under the effects of the biomass-burning, the volume concentration of fine-mode aerosols increased significantly and the PM-fine/PM-coarse volume concentration ratio reached 12.33. This relatively large change in fine-mode particles indicates that biomass-burning has a greater impact on fine-mode aerosols than on coarse-mode aerosols.

He, Q., X. Zhao, J. Lu, G. Zhou, H. Yang, W. Gao, W. Yu, & T. Cheng (2015) Impacts of biomass-burning on aerosol properties of a severe haze event over Shanghai, PARTICUOLOGY (In Press).

Influence of ozone initiated processing on the toxicity of aerosol particles from small scale wood combustion

Abstract - Black carbon containing emissions from biomass combustion are being transformed in the atmosphere upon processing induced by tropospheric ozone and UV. The knowledge today is very limited on how atmospheric processing affects the toxicological properties of the emissions. The aim of this study was to investigate the influence of ozone initiated (dark) atmospheric processing on the physicochemical and toxicological properties of particulate emissions from wood combustion. Emissions from a conventional wood stove operated at two combustion conditions (nominal and hot air starved) were diluted and transferred to a chamber. Particulate matter (PM) was collected before and after ozone addition to the chamber using an impactor. Detailed chemical and physical characterization was performed on chamber air and collected PM. The collected PM was investigated toxicologically in vitro with a mouse macrophage model, endpoints included: cell cycle analysis, viability, inflammation and genotoxicity. The results suggest that changes in the organic fraction, including polycyclic aromatic hydrocarbons (PAHs) are the main driver for differences in obtained toxicological effects. Fresh hot air starved emissions containing a higher organic and PAH mass-fraction affected cell viability stronger than fresh emissions from nominal combustion. The PAH mass fractions decreased upon aging due to chemical degradation. Dark aging increased genotoxicity, reduced viability and reduced release of inflammatory markers. These differences were statistically significant for single doses and typically less pronounced. We hypothesize that the alterations in

toxicity upon simulated dark aging in the atmosphere may be caused by reaction products that form when PAHs and other organic compounds react with ozone and nitrate radicals.

Nordin, E. Z., O. Uski, R. Nyström, P. Jalava, A. C. Eriksson, J. Genberg, P. Roldin, C. Bergvall, R. Westerholm, J. Jokiniemi, J. H. Pagels, C. Boman, & M. Hirvonen (2015) Influence of ozone initiated processing on the toxicity of aerosol particles from small scale wood combustion, ATMOSPHERIC ENVIRONMENT 102:282-289.

Indoor air pollution from burning yak dung as a household fuel in Tibet

Abstract - Yak dung is widely used for cooking and heating in Tibet. We measured real-time concentrations of black carbon (BC) and fine particulate matter with an aerodynamic diameter of 2.5 m or less (PM2.5) emitted by yak dung burning in six households with different living conditions and stove types in the Nam Co region, Tibet. We observed a much lower average BC/PM2.5 mass ratio (0.013, range 0.006–0.028) from dung combustion in this area than previously reported estimates, ranging between 0.05 and 0.11. Based on our measurements, estimated fuel use, and published emission factors of BC and PM2.5, about 0.4–1.7 Gg/year of BC is emitted by yak dung combustion in Tibet in addition to the previously estimated 0.70 Gg/year of BC for Tibetan residential sources. Our survey shows that most residents were aware of adverse health impacts of indoor yak dung combustion and approximately 2/3 of residents had already installed chimney stoves to mitigate indoor air pollution. However, our measurements reveal that, without adequate ventilation, installing a chimney may not ensure good indoor air quality. For instance, the 6-h average BC and PM2.5 concentrations in a stone house using a chimney stove were 24.5 and 873 g/m3, respectively. We also observed a change in the BC/PM2.5 ratios before and after a snow event. The impact of dung moisture content on combustion efficiency and pollutant emissions needs further investigation.

Xiao, Q., E. Saikawa, R. J. Yokelson, P. Chen, C. Li, & S. Kang (2015) Indoor air pollution from burning yak dung as a household fuel in Tibet, ATMOSPHERIC ENVIRONMENT 102:406-412.

Effect of dramatic land use change on gaseous pollutant emissions from biomass burning in Northeastern China

Abstract - Biomass burning contributes a substantial amount of gas and particle emissions to the atmosphere. As China's breadbasket, northeast China has experienced dramatic land use change in the past century, converting approximately 55 104 ha of wetland into farmland to feed a rapidly growing population. This study combines measured emission factors of dominant crops (rice and soybean) and wetland plants (Calamagrostis angu-stifolia, Carex lasiocarpa, Carex pseudo-curaica) and remote sensing land use data to estimate the effect of the unprecedented land use change on gaseous pollutants emissions from biomass burning. Our biomass burning emission estimates resulting from land use changes have increased because of increased post-harvest crop residue burning and decreased burning of wetland plants. From 1986 to 2005, the total emissions of CO2, CO, CXHY, SO2 and NO have increased by 18.6%, 35.7%, 26.8%, 66.2% and 33.2%, respectively. We have found two trends in agricultural burning: increased dryland crop residue burning and decreased wetland (rice paddy) burning. Our results revealed that the large scale land use change in northeastern China has induced more active biomass-burning emissions. The regional emission inventory of gaseous pollutants derived from this work may be used to support further examination of the subsequent effects on regional climate and air quality simulations with numerical atmospheric models.

Zhao, H., D. Q. Tong, C. Gao, & G. Wang (2015) Effect of dramatic land use change on gaseous pollutant emissions from biomass burning in Northeastern China, ATMOSPHERIC RESEARCH 153:429-436.

Lung cancer risk from PAHs emitted from biomass combustion

Abstract - This study deals with the assessment of the cancer risk attributable to PAH exposure, attributable to the increased use of biomass for space heating in Greece in the winter of 2012–2013. Three fractions of particulates (PM1, PM2.5 and PM10) were measured in two sampling sites (urban/residential and traffic-influenced) followed by chemical analysis of 19 PAHs and levoglucosan (used as a biomarker tracer). PAH-induced lung cancer risk was estimated by a comprehensive methodology that incorporated human respiratory tract deposition modelling in order to estimate the

toxic equivalent concentration (TEQ) at each target tissue. This allowed us to further differentiate internal exposure and risk by age groups. Results showed that all PM fractions are higher in Greece during the cold months of the year, mainly due to biomass use for space heating. PAH and levoglucosan levels were highly correlated, indicating that particles emitted from biomass combustion are more toxic than PM emitted from other sources. The estimated lung cancer risk was non-negligible for residents close to the urban background monitoring site. Higher risk was estimated for infants and children, due to the higher bodyweight normalized dose and the human respiratory tract (HRT) physiology. HRT structure and physiology in youngsters favor deposition of particles that are smaller and more toxic per unit mass. In all cases, the estimated risk (5.7E 07 and 1.4E 06 for the urban background site and 1.4E 07 to 5.0E 07 for the traffic site) was lower to the one estimated by the conventional methodology (2.8E 06 and 9.7E 07 for the urban background and the traffic site respectively) that is based on Inhalation Unit Risk; the latter assumes that all PAHs adsorbed on particles are taken up by humans. With the methodology proposed herein, the estimated risk presents a 5–7 times difference between the two sampling sites (depending on the age group). These differences could not have been identified had we relied only on conventional risk assessment method. Consequently, the actual cancer risk attributable to PAHs on PM emitted from biomass burning would have been significantly underestimated.

Sarigiannis, D. A., S. P. Karakitsios, D. Zikopoulos, S. Nikolaki, & M. Kermenidou (2015) *Lung cancer risk from PAHs emitted from biomass combustion,* ENVIRONMENTAL RESEARCH 137:147-156.

WASTE

Uncontrolled combustion of shredded tires in a landfill – Part 1: Characterization of gaseous and particulate emissions

Abstract - In summer 2012, a landfill liner comprising an estimated 1.3 million shredded tires burned in Iowa City, Iowa. During the fire, continuous monitoring and laboratory measurements were used to characterize the gaseous and particulate emissions and to provide new insights into the qualitative nature of the smoke and the quantity of pollutants emitted. Significant enrichments in ambient concentrations of CO, CO2, SO2, particle number (PN), fine particulate (PM2.5) mass, elemental carbon (EC), and polycyclic aromatic hydrocarbons (PAH) were observed. For the first time, PM2.5 from tire combustion was shown to contain PAH with nitrogen heteroatoms (a.k.a. azaarenes) and picene, a compound previously suggested to be unique to coal-burning. Despite prior laboratory studies' findings, metals used in manufacturing tires (i.e. Zn, Pb, Fe) were not detected in coarse particulate matter (PM10) at a distance of 4.2 km downwind. Ambient measurements were used to derive the first in situ fuel-based emission factors (EF) for the uncontrolled open burning of tires, revealing substantial emissions of SO2 (7.1 g kg 1), particle number (3.5   1016 kg 1), PM2.5 (5.3 g kg 1), EC (2.37 g kg 1), and 19 individual PAH (totaling 56 mg kg 1). A large degree of variability was observed in day-to-day EF, reflecting a range of flaming and smoldering conditions of the large-scale fire, for which the modified combustion efficiency ranged from 0.85 to 0.98. Recommendations for future research on this under-characterized source are also provided.

Downard, J., A. Singh, R. Bullard, T. Jayarathne, C. M. Rathnayake, D. L. Simmons, B. R. Wels, S. N. Spak, T. Peters, D. Beardsley, C.s O. Stanier, & E. A. Stone (2015) *Uncontrolled combustion of shredded tires in a landfill – Part 1: Characterization of gaseous and particulate emissions,* ATMOSPHERIC ENVIRONMENT 104:195-204.

Uncontrolled combustion of shredded tires in a landfill – Part 2: Population exposure, public health response, and an air quality index for urban fires

Abstract - The Iowa City Landfill in eastern Iowa, United States, experienced a fire lasting 18 days in 2012, in which a drainage layer of over 1 million shredded tires burned, generating smoke that impacted the surrounding metropolitan area of 130,000 people. This emergency required air monitoring, risk assessment, dispersion modeling, and public notification. This paper quantifies the

impact of the fire on local air quality and proposes a monitoring approach and an Air Quality Index (AQI) for use in future tire fires and other urban fires. Individual fire pollutants are ranked for acute and cancer relative risks using hazard ratios, with the highest acute hazard ratios attributed to SO2, particulate matter, and aldehydes. Using a dispersion model in conjunction with the new AQI, we estimate that smoke concentrations reached unhealthy outdoor levels for sensitive groups out to distances of 3.1 km and 18 km at 24-h and 1-h average times, respectively. Modeled and measured concentrations of PM2.5 from smoke and other compounds such as VOCs and benzo[a]pyrene are presented at a range of distances and averaging times, and the corresponding cancer risks are discussed. Through reflection on the air quality response to the event, consideration of cancer and acute risks, and comparison to other tire fires, we recommend that all landfills with shredded tire liners plan for hazmat fire emergencies. A companion paper presents emission factors and detailed smoke characterization.

Singh, A., S. N. Spak, E. A. Stone, J. Downard, R. L. Bullard, M. Pooley, P. A. Kostle, M. W. Mainprize, M. D. Wichman, T. M. Peters, D. Beardsley, & C. O. Stanier (2015) *Uncontrolled combustion of shredded tires in a landfill – Part 2: Population exposure, public health response, and an air quality index for urban fires*, ATMOSPHERIC ENVIRONMENT 104:273-283.

TRANSPORT & INDUSTRY

Evolution of on-road vehicle exhaust emissions in Delhi

Abstract - For a 40-year horizon (1990–2030), on-road vehicle exhaust emissions were evaluated, retrospectively and prospectively, for the largest urban agglomeration in India – the Greater Delhi region with a combined population of 22 million in 2011 (Delhi along with Ghaziabad, Noida, Greater Noida, Faridabad and Gurgaon). Emissions of particulate matter, sulfur dioxide, carbon monoxide and volatile organic compounds (VOCs) reached their peak during late 1990s through early 2000s after which they reduced significantly through year 2012. On the other hand, nitrogen oxides (NOx) and carbon dioxide show an increasing trend. The most reduction in emissions between 1998 and 2012 occurred as a result of implementation of four sets of vehicular emission standards, removal of lead, reduction of sulfur content, mandatory retirement of older commercial vehicles, and conversion of diesel and petrol run public transport vehicles to compressed natural gas. In addition, changes in the vehicular technology have also contributed to controlling emissions especially in case of auto-rickshaws and motorized two-wheelers, which changed from two-stroke to four-stroke. The rising trend of NOx along with the presence of VOCs indicates increasing tendency to form ground-level ozone and as a result, smog in the region. We predict that the current regime of vehicle technology, fuel standards, and high growth rate of private vehicles, is likely to nullify all the past emission reductions by the end of 2020s.

Goel, R., & S. K. Guttikunda (2015) *Evolution of on-road vehicle exhaust emissions in Delhi*, ATMOSPHERIC ENVIRONMENT 105:78-90.

On-road emission characteristics of VOCs from rural vehicles and their ozone formation potential in Beijing, China

Abstract - This paper is the second in a series of papers aimed at understanding volatile organic compound (VOC) emissions from motor vehicles in Beijing using on-board emission measurements, focusing specifically on rural vehicles (RVs). In this work, 13 RVs, including 6 different 3-wheel (3-W) RVs and 7 different 4-wheel (4-W) RVs, were examined using a portable emissions measurement system (PEMS) as the vehicles were driven on predesigned fixed test routes in rural areas of Beijing. Overall, 50 VOC species were quantified in this study, including 18 alkanes, 5 alkenes, 11 aromatics, 13 carbonyls and 3 other compounds. The average emission factor (EF) of the total VOCs for the 4-W RVs based on the distance traveled was 326.2   129.3 mg/km, which is 2.5 times greater than that of the 3-W RVs. However, the VOC emissions for the 3-W RVs had higher EFs based on their CO2

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emissions due to the different fuel economies of the two types of RVs. Formaldehyde, toluene, acetaldehyde, m-xylene, p-xylene, isopentane, benzene, ethylbenzene, n-pentane, 2-methoxy-2-methylpropane and butenal were the dominant VOC species from the RVs, accounting for an average of 68.6% of the total VOC emissions. Overall, the RVs had high proportions of aromatics and carbonyls. The ozone formation potentials (OFPs) were 670.6　227.2 and 1454.1　643.0 mg O3/km for the 3-W and 4-W RVs, respectively, and approximately 60%–70% of the OFP resulted from carbonyls. We estimated that the 3-W and 4-W RVs accounted for approximately 50% and 10%, respectively, of the total OFP caused by diesel vehicles (including diesel trucks and RVs) in Beijing in 2012. Thus, more attention should be given to VOC emissions and their impact on ozone formation.

Yao, Z., B. Wu, X. Shen, X. Cao, X. Jiang, Y. Ye, & K. He (2015) On-road emission characteristics of VOCs from rural vehicles and their ozone formation potential in Beijing, China, ATMOSPHERIC ENVIRONMENT 105:91-96.

Fuel quality management versus vehicle emission control in China, status quo and future perspectives

Abstract - China's fuel quality standards and fuel supply management have long been an impediment to improved air quality by hindering the progress of vehicle emission control. This paper summarizes the status of China's fuel quality standards, fuel supply and vehicle emission standards focusing on the major problems of fuel quality management. The mechanism that China uses to establish its fuel quality standards is outlined. The gaming of stakeholders such as regulatory authorities, vehicle and engine manufacturers and the gigantic state-owned oil companies in the development of fuel quality standard formulation and fuel supply is illustrated. Results are presented from testing 59 gasoline samples for sulphur, olefins, aromatics, benzene, and manganese content and from testing 59 diesel samples for sulphur and polyaromatic hydrocarbons collected across the country from 2010 to 2011. This paper also provides key policy suggestions to improve future fuel quality in China. China should improve fuel quality through the application of policy measures such as adjusting the fuel quality standard formulation process, introducing competition and enforcing the transition period for improved fuel introduction, unifying on-road diesel and non-road diesel fuel quality standards, and pay attention to issues like fuel detergent, methanol addition and evaporative emissions.

Yue, X., Y. Wu, J. Hao, Y. Pang, Y. Ma, Y. Li, B. Li, & X. Bao (2015) Fuel quality management versus vehicle emission control in China, status quo and future perspectives, ENERGY POLICY 79:87-98.

FOSSIL FUELS

Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Liquid Unloadings

Abstract - Methane emissions from liquid unloadings were measured at 107 wells in natural gas production regions throughout the United States. Liquid unloadings clear wells of accumulated liquids to increase production, employing a variety of liquid lifting mechanisms. In this work, wells with and without plunger lifts were sampled. Most wells without plunger lifts unload less than 10 times per year with emissions averaging 21 000 35 000 scf methane (0.4 0.7 Mg) per event (95% confidence limits of 10 000 50 000 scf/event). For wells with plunger lifts, emissions averaged 1000 10 000 scf methane (0.02 0.2 Mg) per event (95% confidence limits of 500 12 000 scf/event). Some wells with plunger lifts are automatically triggered and unload thousands of times per year and these wells account for the majority of the emissions from all wells with liquid unloadings. If the data collected in this work are assumed to be representative of national populations, the data suggest that the central estimate of emissions from unloadings (270 Gg/yr, 95% confidence range of 190　400 Gg) are within a few percent of the emissions estimated in the EPA 2012 Greenhouse Gas National Emission Inventory (released in 2014), with emissions dominated by wells with high frequencies of unloadings.

Allen, D. T., D. W. Sullivan, D. Zavala-Araiza, A. P. Pacsi, M. Harrison, K. Keen, M. P. Fraser, A. D. Hill B. K. Lamb, R. F. Sawyer, & J. H. Seinfeld (2015) *Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Liquid Unloadings*, ENVIRON. SCI. TECHNOL. 49:641 648.

Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts

Abstract - Methane emissions from natural gas delivery and end use must be quantified to evaluate the environmental impacts of natural gas and to develop and assess the efficacy of emission reduction strategies. We report natural gas emission rates for 1 y in the urban region of Boston, using a comprehensive atmospheric measurement and modeling framework. Continuous methane observations from four stations are combined with a high-resolution transport model to quantify the regional average emission flux, 18.5 3.7 (95% confidence interval) g CH_4 m 2 y 1 . Simultaneous observations of atmospheric ethane, compared with the ethane-to-methane ratio in the pipeline gas delivered to the region, demonstrate that natural gas accounted for ~ 60–100% of methane emissions, depending on season. Using government statistics and geospatial data on natural gas use, we find the average fractional loss rate to the atmosphere from all downstream components of the natural gas system, including transmission, distribution, and end use, was 2.7 0.6% in the Boston urban region, with little seasonal variability. This fraction is notably higher than the 1.1% implied by the most closely comparable emission inventory

McKaina, K., A. Down, S. M. Racitie, J. Budneya, L. R. Hutyrae, C. Floerchingerg, S. C. Herndong, T. Nehrkornh, M. S. Zahniserg, R. B. Jackson, N. Phillipse, & S. C. Wofsya (2015) *Methane emissions from natural gas infrastructure and use in the urban region of Boston, Massachusetts*, PNAS 112(7):1941-1946.

Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania

Abstract - Abandoned oil and gas wells provide a potential pathway for subsurface migration and emissions of methane and other fluids to the atmosphere. Little is known about methane fluxes from the millions of abandoned wells that exist in the United States. Here, we report direct measurements of methane fluxes from abandoned oil and gas wells in Pennsylvania, using static flux chambers. A total of 42 and 52 direct measurements were made at wells and at locations near the wells ("controls") in forested, wetland, grassland, and river areas in July, August, October 2013 and January 2014, respectively. The mean methane flow rates at these well locations were 0.27 kg/d/well, and the mean methane flow rate at the control locations was 4.5 10 6 kg/d/location. Three out of the 19 measured wells were high emitters that had methane flow rates that were three orders of magnitude larger than the median flow rate of 1.3 10 3 kg/d/well. Assuming the mean flow rate found here is representative of all abandoned wells in Pennsylvania, we scaled the methane emissions to be 4–7% of estimated total anthropogenic methane emissions in Pennsylvania. The presence of ethane, propane, and n-butane, along with the methane isotopic composition, indicate that the emitted methane is predominantly of thermogenic origin. These measurements show that methane emissions from abandoned oil and gas wells can be significant. The research required to quantify these emissions nationally should be undertaken so they can be accurately described and included in greenhouse gas emissions inventories.

Kanga, M. Cynthia M. Kannoa, Matthew C. Reida,3, Xin Zhangb, Denise L. Mauzeralla,b,1, Michael A. Celiaa, Yuheng Chenc, and Tullis C. Onstottc (2015) *Direct measurements of methane emissions from abandoned oil and gas wells in Pennsylvania*, PNAS 111(51):18173–18177.

Effects of oxygenated fuel blends on carbonaceous particulate composition and particle size distributions from a stationary diesel engine

Abstract - A systematic study was conducted to evaluate and compare the effects of blending five different oxygenated compounds, diglyme (DGM), palm oil methyl ester (PME), dimethyl carbonate (DMC), diethyl adipate (DEA) and butanol (Bu) with ultralow sulfur diesel (ULSD), on engine performance, particulate mass concentrations, organic (OC) and elemental (EC) carbon fractions of the particles and particle size distributions from a single cylinder, direct injection stationary diesel engine with the engine working at a constant engine speed and at three engine loads. A small increase in the brake specific fuel consumption (BSFC) and brake thermal efficiency (BTE) was

observed with the use of oxygenates blended with ULSD. All five oxygenates were found to be effective at reducing particulate mass emissions at medium and high engine loads, with butanol being the most effective and DGM being the least effective. Analysis of the relative contribution of changes in the OC and EC emissions to the reduction of particulate matter indicated that under the same oxygen content, EC made a dominant contribution to the reduction of particulate mass. The results also indicated that reduction in both particle mass and number emissions was affected not only by the oxygen content, but also by the chemical structure and thermophysical properties of oxygenates as well as engine operating conditions.

Zhang, Z., & R. Balasubramanian (2015) Effects of oxygenated fuel blends on carbonaceous particulate composition and particle size distributions from a stationary diesel engine, FUEL 141:1-8.

CROSS CUTTING, OTHER SLCP SOURCE SECTORS & SLCP VULNERABLE REGIONS

Modeling California policy impacts on greenhouse gas emissions

Abstract - This paper examines policy and technology scenarios in California, emphasizing greenhouse gas (GHG) emissions in 2020 and 2030. Using CALGAPS, a new, validated model simulating GHG and criteria pollutant emissions in California from 2010 to 2050, four scenarios were developed: Committed Policies (S1), Uncommitted Policies (S2), Potential Policy and Technology Futures (S3), and Counterfactual (S0), which omits all GHG policies. Forty-nine individual policies were represented. For S1–S3, GHG emissions fall below the AB 32 policy 2020 target [427 million metric tons CO2 equivalent (MtCO2e) yr 1], indicating that committed policies may be sufficient to meet mandated reductions. In 2030, emissions span 211–428 MtCO2e yr 1, suggesting that policy choices made today can strongly affect outcomes over the next two decades. Long-term (2050) emissions were all well above the target set by Executive Order S-3-05 (85 MtCO2e yr 1); additional policies or technology development (beyond the study scope) are likely needed to achieve this objective. Cumulative emissions suggest a different outcome, however: due to early emissions reductions, S3 achieves lower cumulative emissions in 2050 than a pathway that linearly reduces emissions between 2020 and 2050 policy targets. Sensitivity analysis provided quantification of individual policy GHG emissions reduction benefits.

Greenblatt, J. B. (2015) Modeling California policy impacts on greenhouse gas emissions, ENERGY POLICY 78:158-172.

Proposals to enhance thermal efficiency programs and air pollution control in south-central Chile

Abstract - Major cities in South-central Chile suffer high levels of particulate matter PM10 and PM2.5 due to combustion of solid fuels for heating. Exposure to these air pollutants is recognized as a major contribution to ill health in the region. Here we discuss new strategies to reduce air pollution. Regulations and subsidies focusing on improved combustion by providing drier wood fuel and better stoves have been in effect since 2007. However, air pollution due to combustion of wood fuel has been steadily rising, along with reports on health consequences. The paper analyzes a survey of 2025 households in the city of Valdivia, which found that wood fuel quality, stove renewal, and awareness of programs are strongly affected by income level, and that higher consumption of wood fuel is found in households already having better stoves and drier wood fuel. The analysis suggests that regulations intended to improve combustion are influenced by user's behavior and have limited potential for lowering pollution. We conclude that thermal refurbishment has a larger potential for improvement, not yet been implemented as an energy policy for the majority. Here we propose improvements and additions to current programs to enhance effectiveness and cover the whole social spectrum.

Schueftan, A., & A. D. González (2015) Proposals to enhance thermal efficiency programs and air pollution control in south-central Chile, ENERGY POLICY 79:48-57.

Review on urban vegetation and particle air pollution – Deposition and dispersion

Abstract - Urban vegetation affects air quality through influencing pollutant deposition and dispersion. Both processes are described by many existing models and experiments, on-site and in wind tunnels, focussing e.g. on urban street canyons and crossings or vegetation barriers adjacent to traffic sources. There is an urgent need for well-structured experimental data, including detailed empirical descriptions of parameters that are not the explicit focus of the study.

This review revealed that design and choice of urban vegetation is crucial when using vegetation as an ecosystem service for air quality improvements. The reduced mixing in trafficked street canyons on adding large trees increases local air pollution levels, while low vegetation close to sources can improve air quality by increasing deposition. Filtration vegetation barriers have to be dense enough to offer large deposition surface area and porous enough to allow penetration, instead of deflection of the air stream above the barrier. The choice between tall or short and dense or sparse vegetation determines the effect on air pollution from different sources and different particle sizes.

Black carbon emissions reductions from combustion of alternative jet fuels

Abstract - Recent measurement campaigns for alternative aviation fuels indicate that black carbon emissions from gas turbines are reduced significantly with the use of alternative jet fuels that are low in aromatic content. This could have significant climate and air quality-related benefits that are currently not accounted for in environmental assessments of alternative jet fuels. There is currently no predictive way of estimating aircraft black carbon emissions given an alternative jet fuel. We examine the results from available measurement campaigns and propose a first analytical approximation (termed 'ASAF') of the black carbon emissions reduction associated with the use of paraffinic alternative jet fuels. We establish a relationship between the reduction in black carbon emissions relative to conventional jet fuel for a given aircraft, thrust setting relative to maximum rated thrust, and the aromatic volume fraction of the (blended) alternative fuel. The proposed relationship is constrained to produce physically meaningful results, makes use of only one free parameter and is found to explain a majority of the variability in measurements across the engines and fuels that have been tested.

Representativeness of air quality monitoring networks

Abstract - The suitability of European networks to check compliance with air quality standards and to assess exposure of the population was investigated. An air quality model (URBIS) was applied to estimate and compare the spatial distribution of the concentration of nitrogen dioxide (NO2) in ambient air in four large cities. The concentrations calculated at the location of the monitoring stations, compared well with the concentrations measured at the stations indicating that the models worked well. Therefore the calculated concentration distributions were used as a proxy for the actual concentration distributions across the cities. The distributions of these proxy concentrations across the city populations was determined and cumulative population distribution curves were estimated. The calculated annual mean values at the monitoring network stations were located on the population distribution curves to estimate the fractions of the populations that the monitoring network stations represent. This macro scale procedure is used to evaluate which subgroups of the monitoring stations can be reliably used to decide on compliance or to estimate the concentration the population is exposed to. In addition, the CAR model and Computational Fluid Dynamics (CFD) models are used to investigate the effect of micro scale siting of the monitoring stations within the streets.

The following observations were made:

- Berlin and London networks cover the distribution of concentrations to which the population is exposed rather well, while Stuttgart and Barcelona have stations at sites with mainly the higher concentrations and the exposure is covered less well.

- The networks in London and Berlin, with a substantial number of urban background stations, seem fit to monitor the average population exposure, contrary to those in Stuttgart and Barcelona with only a limited number of these stations.

- The concentrations measured at street stations hardly reflect the calculated differences in street pollution between the cities. In Stuttgart the stations are, in line with the EU directive, placed in the most polluted streets, while in other cities there are no stations in the streets with the highest pollution levels.

- The concentrations measured at street stations – particularly where buildings inhibit ventilation – are very sensitive to the exact location within the street. Different siting choices may have an effect that for NO2 could reach up to 10 g/m3 in realistic conditions. Street stations, representing only a small urban area, are not suitable for characterising the exposure of the general population.

It is important to note that epidemiological studies whether investigating short term-effects or those studying long-term effects are potentially affected by the issues raised in the paper. Long-term cumulative exposure estimates that are based rather uncritically on monitoring data may be biased if the stations are not representative. It is recommended to use models to support the interpretation and spatial extrapolation of the results of measurements in existing networks. The use of models also relaxes the need for station relocation in inadequate networks, which often would compromise trend analysis. It also relaxes the importance of exact or detailed, comprehensive, station classifications since all stations can be used in exposure assessments

Duyzer, J., D. van den Hout, P. Zandveld, & S. van Ratingen (2015) *Representativeness of air quality monitoring networks*, ATMOSPHERIC ENVIRONMENT 104:88-101.

PM emissions measurements of in-service commercial aircraft engines during the Delta-Atlanta Hartsfield Study

Abstract - This paper describes the results of the physical characterization of aircraft engine PM emission measurements conducted during the Delta-Atlanta Hartsfield Study at the Hartsfield-Jackson Atlanta International Airport. Engine exit plane PM emissions were sampled from on-wing engines on several in-service commercial transport aircraft from the fleet of Delta Airlines. The size distributions were lognormal in nature with a single mode. The geometric mean diameter was found to increase with increasing engine thrust, ranging from 15 nm at idle to 40 nm at takeoff. PM number- and mass-based emission indices were observed to be higher at the idle conditions (4% and 7%), lowest at 15%–30% thrust, and then increase with increasing thrust. Emissions measurements were also conducted during an advected plume study where over 300 exhaust plumes generated by a broad mix of commercial transports were sampled 100–350 m downwind from aircraft operational runways during normal airport operations. The range of values measured at take-off for the different engine types in terms of PM number-based emission index was between 7 1015–9 1017 particles/kg fuel burned, and that for PM mass-based emission index was 0.1–0.6 g/kg fuel burned. PM characteristics of aircraft engine specific exhaust were found to evolve over time as the exhaust plume expands, dilutes with ambient air, and cools. The data from these measurements will enhance the emissions inventory development for a subset of engines operating in the commercial fleet and improve/validate current environmental impact predictive tools with real world aircraft engine specific PM emissions inputs.

Lobo, P., D. E. Hagen, P. D. Whitefield, & D. Raper (2015) *PM emissions measurements of in-service commercial aircraft engines during the Delta-Atlanta Hartsfield Study*, ATMOSPHERIC ENVIRONMENT 104:237-245.

Emission inventory of non-methane volatile organic compounds from anthropogenic sources in India

Abstract - This paper presents a new inventory of NMVOC emissions from anthropogenic sources in India for the year 2010. The main new element of this inventory, compared to previous work for India, is the use of new and more detailed data on solvent use sectors and oil production and distribution system. The results are presented at the national and state level for major sectors and VOC species. Finally, the annual emissions were spatially distributed at a fine resolution of 36 36 km2 using detailed spatial information. The total anthropogenic NMVOC emissions in India in 2010 were estimated at 9.81 Tg which is in the range of the estimates made in most other studies. The

majority of emissions (60%) originated from residential combustion of biomass for cooking. Solvent use sectors and oil production and distribution contributed about 20% followed by transport (12%) and open burning of agricultural residues (7%). Specie-wise distribution shows highest contribution from alkenes and alkynes (38%), followed by alkanes (22%), and aromatics (16%).

Sharma, S., A. Goel, D. Gupta, A. Kumar, A. Mishra, S. Kundu, S. Chatani, & Z. Klimont (2015) *Emission inventory of non-methane volatile organic compounds from anthropogenic sources in India*, ATMOSPHERIC ENVIRONMENT 102:209-219.

Characterization of particles from a marine engine operating at low loads

Abstract - Particle emissions from a marine diesel engine operating at low loads with four different fuels were characterized with respect to particle number (PN) and particle mass (PM), size distribution, volatility and chemical composition. The four different fuels used were Swedish Environmental class 1 (MK1) and class 3 diesel (MK3), heavy fuel oil (HFO, 0.12 wt% S) and marine diesel oil (MDO, 0.52 wt% S). The measurements were performed for a marine diesel engine in a test-bed engine lab and the particle emissions were measured with an Engine Exhaust Particle Sizer and a Dust Monitor, giving the number concentrations in the size range of 5.6–560 nm and 300 nm to 20 m, respectively. To quantify the amount of solid particles a thermodenuder was used. Additionally, filter samples were taken for gravimetric, black carbon (BC) and elemental analysis. The particle emissions showed a bimodal size distribution by number and the number concentrations were dominated by nanoparticles (diameter (Dp) < 50 nm). The nanoparticles measured were both primary and secondary particles, depending on fuel and engine load, while the particles with Dp > 50 nm generally were solid primary particles. Combustion of HFO resulted in the highest PN and PM concentrations. Emission factors (EFs) for PM and PN for both the total particle emissions and the fraction of primary, solid particles are presented for different fuels and loads. EFs for nitrogen oxides (NOx), BC and some elements (Ca, Fe, V, Ni, Zn) are presented as well. This study contributes to understanding particle emissions from potential future fuels as well as emissions in ports and coastal areas where lower engine loads are common.

Anderson, M., K. Salo, Å. M. Hallquist, & E. Fridell (2015) *Characterization of particles from a marine engine operating at low loads*, ATMOSPHERIC ENVIRONMENT 101:65-71.

Modelling of ship engine exhaust emissions in ports and extensive coastal waters based on terrestrial AIS data – An Australian case study

Abstract - A model is developed to calculate and spatially allocate ship engine exhaust emissions in ports and extensive coastal waters using terrestrial Automatic Identification System data for ship movements and operating modes. The model is applied to the Australian region. The large geographical extent and number of included ports and vessels, and anomalies in the AIS data are challenging. Particular attention is paid to filtering of the movement data to remove anomalies and assign correct operating modes. Data gaps are filled by interpolation and extrapolation. Emissions and fuel consumption are calculated for each individual vessel at frequent intervals and categorised by ship type, ship size, operating mode and machinery type. Comparisons of calculated port emissions with conventional inventories and ship visit data are favourable. Estimations of ship emissions from regions within a 300 km radius of major capital cities suggest that a non-negligible percentage of air pollutants may come from ships.

Goldsworthy, L., & B. Goldsworthy (2015) *Modelling of ship engine exhaust emissions in ports and extensive coastal waters based on terrestrial AIS data – An Australian case study*, ENVIRONMENTAL MODELLING & SOFTWARE 63:45-60.