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

SLCP Research Digest

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SHORT-LIVED CLIMATE POLLUTANTS

Trends in multi-pollutant emissions from a technology-linked inventory for India: I. Industry and transport sectors

Abstract - Emissions estimation, for research and regulatory applications including reporting to international conventions, needs treatment of detailed technology divisions and high-emitting technologies. Here we estimate Indian emissions, for 1996–2015, of aerosol constituents (PM2.5, BC and OC) and precursor gas SO2, ozone precursors (CO, NOx, NMVOC and CH4) and greenhouse gases (CO2 and N2O), using a common fuel consumption database and consistent assumptions. Six source categories and 45 technologies/activities in the industry and transport sectors were used for estimating emissions for 2010. Mean emission factors, developed at the source-category level, were used with corresponding fuel consumption data, available for 1996–2011, projected to 2015. New activities were included to account for fugitive emissions of NMVOC from chemical and petrochemical industries. Dynamic emission factors, reflecting changes in technology-mix and emission regulations, were developed for thermal power plants and on-road transport vehicles. Modeled emission factors were used for gaseous pollutants for on-road vehicles. Emissions of 2.4 (0.6–7.5) Tg y 1 PM2.5, 0.23 (0.1–0.7) Tg y 1 BC, 0.15 (0.04–0.5) Tg y 1 OC, 7.3 (6–10) Tg y 1 SO2, 19 (7.5–33) Tg y 1 CO, 1.5 (0.1–9) Tg y 1 CH4, 4.3 (2–9) Tg y 1 NMVOC, 5.6 (1.7–15.9) Tg y 1 NOx, 1750 (1397–2231) Tg y 1 CO2 and 0.13 (0.05–0.3) Tg y 1 N2O were estimated for 2015. Significant emissions of aerosols and their precursors were from coal use in thermal power and industry (PM2.5 and SO2), and on-road diesel vehicles (BC), especially superemitters. Emissions of ozone precursors were largely from thermal power plants (NOx), on-road gasoline vehicles (CO and NMVOC) and fugitive emissions from mining (CH4). Highly uncertain default emission factors were the principal contributors to uncertainties in emission estimates, indicating the need for region specific measurements.

Pankaj Sadavarte, P., & C. Venkataraman (2014) Trends in multi-pollutant emissions from a technology-linked inventory for India: I. Industry and transport sectors, ATMOSPHERIC ENVIRONMENT 99:353-364.

Trends in multi-pollutant emissions from a technology-linked inventory for India: II. Residential, agricultural and informal industry sectors

Abstract - Dispersed traditional combustion technologies, characterized by inefficient combustion and significant emissions, are widely used in residential cooking and "informal industries" including brick production, food and agricultural product processing operations like drying and cooking operations related to sugarcane juice, milk, food-grain, jute, silk, tea and coffee. In addition, seasonal agricultural residue burning in field is a discontinuous source of significant emissions. Here we estimate fuel consumption in these sectors and agricultural residue burned using detailed technology divisions and survey-based primary data for 2010 and projected between 1996 and 2015. In the residential sector, a decline in the fraction of solid biomass users for cooking from 79% in 1996 to 65% in 2010 was offset by a growing population, leading to a nearly constant population of solid biomass users, with a corresponding increase in the population of LPG users. Emissions from agriculture followed the growth in agricultural production and diesel use by tractors and pumps. Trends in emissions from the informal industries sector followed those in coal combustion in brick kilns. Residential biomass cooking stoves were the largest contributors to emissions of PM2.5, OC, CO, NMVOC and CH4. Highest emitting technologies of BC were residential kerosene wick lamps. Emissions of SO2 were largely from coal combustion in Bull's trench kilns and other brick manufacturing technologies. Diesel use in tractors was the major source of NOx emissions. Uncertainties in emission estimates were principally from highly uncertain emission factors, particularly for technologies in the informal industries.

Pandey, A., P. Sadavarte, A. B. Rao, & C. Venkataraman (2014) Trends in multi-pollutant emissions from a technology-linked inventory for India: II. Residential, agricultural and informal industry sectors, ATMOSPHERIC ENVIRONMENT 99:341-352.

Disentangling the effects of CO_2 and short-lived climate forcer mitigation

Abstract - Anthropogenic global warming is driven by emissions of a wide variety of radiative forcers ranging from very short-lived climate forcers (SLCFs), like black carbon, to very long-lived, like CO2. These species are often released from common sources and are therefore intricately linked. However, for reasons of simplification, this CO2–SLCF linkage was often disregarded in long-term projections of earlier studies. Here we explicitly account for CO2–SLCF linkages and show that the short- and long-term climate effects of many SLCF measures consistently become smaller in scenarios that keep warming to below 2 C relative to preindustrial levels. Although long-term mitigation of methane and hydrofluorocarbons are integral parts of 2 C scenarios, early action on these species mainly influences near-term temperatures and brings small benefits for limiting maximum warming relative to comparable reductions taking place later. Furthermore, we find that maximum 21stcentury arming in 2 C-consistent scenarios is largely unaffected by additional black-carbon-related measures because key emission sources are already phased-out through CO2 mitigation. Our study demonstrates the importance of coherently considering CO2–SLCF coevolutions. Failing to do so leads to strongly and consistently overestimating the effect of SLCF measures in climate stabilization scenarios. Our results reinforce that SLCF measures are to be considered complementary rather than a substitute for early and stringent CO2 mitigation. Near-term SLCF measures do not allow for more time for CO2 mitigation. We disentangle and resolve the distinct benefits across different species and therewith facilitate an integrated strategy for mitigating both short and long-term climate change.

Rogelj, J., M. Schaeffer, M. Meinshausen, D. T. Shindell, W. Hare, Z. Klimont, G. J. M. Velders, M. Amann, & H. J. Schellnhuber (2014) Disentangling the effects of CO_2 and short-lived climate forcer mitigation, PNAS 111(46):16325-16330.

Recent climate and air pollution impacts on Indian agriculture

Abstract - Recent research on the agricultural impacts of climate change has primarily focused on the roles of temperature and precipitation. These studies show that India has already been negatively affected by recent climate trends. However, anthropogenic climate changes are a result of both global emissions of long-lived greenhouse gases (LLGHGs) and other short-lived climate pollutants (SLCPs). Two potent SLCPs, tropospheric ozone and black carbon, have direct effects on crop yields beyond their indirect effects through climate; emissions of black carbon and ozone precursors have risen dramatically in India over the past three decades. Here, to our knowledge for the first time, we present results of the combined effects of climate change and the direct effects of SLCPs on wheat and rice yields in India from 1980 to 2010. Our statistical model suggests that, averaged over India, yields in 2010 were up to 36% lower for wheat than they otherwise would have been, absent climate and pollutant emissions trends, with some densely populated states experiencing 50% relative yield losses. [Our point estimates for rice (20%) are similarly large, but not statistically significant.] Upper-bound estimates suggest that an overwhelming fraction (90%) of these losses is due to the direct effects of SLCPs. Gains from addressing regional air pollution could thus counter expected future yield losses resulting from direct climate change effects of LLGHGs.

Burney, J. & V. Ramanathan (2014) Recent climate and air pollution impacts on Indian agriculture, PNAS 111(46)16319-16324

High winter ozone pollution from carbonyl photolysis in an oil and gas basin

Abstract - The United States is now experiencing the most rapid expansion in oil and gas production in four decades, owing in large part to implementation of new extraction technologies such as horizontal drilling combined with hydraulic fracturing. The environmental impacts of this development, from its effect on water quality1 to the influence of increased methane leakage on climate2, have been a matter of intense debate. Air quality impacts are associated with emissions of

nitrogen oxides3, 4 (NOx = NO + NO2) and volatile organic compounds5, 6, 7 (VOCs), whose photochemistry leads to production of ozone, a secondary pollutant with negative health effects8. Recent observations in oil- and gas-producing basins in the western United States have identified ozone mixing ratios well in excess of present air quality standards, but only during winter9, 10, 11, 12, 13. Understanding winter ozone production in these regions is scientifically challenging. It occurs during cold periods of snow cover when meteorological inversions concentrate air pollutants from oil and gas activities, but when solar irradiance and absolute humidity, which are both required to initiate conventional photochemistry essential for ozone production, are at a minimum. Here, using data from a remote location in the oil and gas basin of northeastern Utah and a box model, we provide a quantitative assessment of the photochemistry that leads to these extreme winter ozone pollution events, and identify key factors that control ozone production in this unique environment. We find that ozone production occurs at lower NOx and much larger VOC concentrations than does its summertime urban counterpart, leading to carbonyl (oxygenated VOCs with a C = O moiety) photolysis as a dominant oxidant source. Extreme VOC concentrations optimize the ozone production efficiency of NOx. There is considerable potential for global growth in oil and gas extraction from shale. This analysis could help inform strategies to monitor and mitigate air quality impacts and provide broader insight into the response of winter ozone to primary pollutants.

Edwards, P. M., S S. Brown, J. M. Roberts, R. Ahmadov, R. M. Banta, J. A. deGouw, W. P. Dubé, R. A. Field, J. H. Flynn, J. B. Gilman, M. Graus, D. Helmig, A. Koss, A. O. Langford, B. L. Lefer, B. M. Lerner, R. Li, S.-M. Li, S. A. McKeen, S. M. Murphy, D. D. Parrish, C. J. Senff, J. Soltis, J. Stutz, C. Sweeney (2014) High winter ozone pollution from carbonyl photolysis in an oil and gas basin, NATURE 514:351–354.

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BLACK CARBON

Exploiting simultaneous observational constraints on mass and absorption to estimate the global direct radiative forcing of black carbon and brown carbon

Abstract - Atmospheric black carbon (BC) is a leading climate warming agent, yet uncertainties on the global direct radiative forcing (DRF) remain large. Here we expand a global model simulation (GEOS-Chem) of BC to include the absorption enhancement associated with BC coating and separately treat both the aging and physical properties of fossil-fuel and biomass-burning BC. In addition we develop a global simulation of brown carbon (BrC) from both secondary (aromatic) and primary (biomass burning and biofuel) sources. The global mean lifetime of BC in this simulation (4.4 days) is substantially lower compared to the AeroCom I model means (7.3 days), and as a result, this model captures both the mass concentrations measured in near-source airborne field campaigns (ARCTAS, EUCAARI) and surface sites within 30%, and in remote regions (HIPPO) within a factor of 2. We show that the new BC optical properties together with the inclusion of BrC reduces the model bias in absorption aerosol optical depth (AAOD) at multiple wavelengths by more than 50% at AERONET sites worldwide. However our improved model still underestimates AAOD by a factor of 1.4 to 2.8 regionally, with the largest underestimates in regions influenced by fire. Using the RRTMG model integrated with GEOS-Chem we estimate that the all-sky top-of-atmosphere DRF of BC is +0.13 Wm 2 (0.08 Wm 2 from anthropogenic sources and 0.05 Wm 2 from biomass burning). If we scale our model to match AERONET AAOD observations we estimate the DRF of BC is +0.21 Wm 2, with an additional +0.11 Wm 2 of warming from BrC. Uncertainties in size, optical properties, observations, and emissions suggest an overall uncertainty in BC DRF of 80%/+140%. Our estimates are at the lower end of the 0.2–1.0 Wm 2 range from previous studies, and substantially less than the +0.6 Wm 2 DRF estimated in the IPCC 5th Assessment Report. We suggest that the DRF of BC has previously been overestimated due to the overestimation of the BC lifetime (including the effect on the vertical profile) and the incorrect attribution of BrC absorption to BC.

Wang, X., C. L. Heald, D. A. Ridley, J. P. Schwarz, J. R. Spackman, A. E. Perring, H. Coe, D. Liu, & A. D. Clarke (2014) Exploiting simultaneous observational constraints on mass and absorption to estimate the global direct radiative forcing of black carbon and brown carbon, ATMOSPHERIC CHEMISTRY AND PHYSICS 14:10989-11010.

How shorter black carbon lifetime alters its climate effect

Abstract - Black carbon (BC), unlike most aerosol types, absorbs solar radiation. However, the quantification of its climate impact is uncertain and presently under debate. Recently, attention has been drawn both to a likely underestimation of global BC emissions in climate models, and an overestimation of BC at high altitudes. Here we show that doubling present day BC emissions in a model simulation, while reducing BC lifetime based on observational evidence, leaves the direct aerosol effect of BC virtually unchanged. Increased emissions, together with increased wet removal that reduces the lifetime, yields modelled BC vertical profiles that are in strongly improved agreement with recent aircraft observations. Furthermore, we explore the consequences of an altered BC profile in a global circulation model, and show that both the vertical profile of BC and rapid climate adjustments need to be taken into account in order to assess the total climate impact of BC.

Hodnebrog, O., G. Myhre, & B. H. Samset (2014) How shorter black carbon lifetime alters its climate effect, NATURE COMMUNICATIONS 5(5065).

Characteristics of black carbon aerosol in Jiaxing, China during autumn 2013

Abstract - We conducted measurements of black carbon (BC) aerosol in Jiaxing, China during autumn from September 26 to November 30, 2013. We investigated temporal and diurnal variations of BC, and its correlations with meteorological parameters and other major pollutants. Results showed that hourly mass concentrations of BC ranged from 0.2 to 22.0 μg/m3, with an average of 5.1 μg/m3. The diurnal variation of BC exhibited a bimodal distribution, with peaks at 07:00 and 18:00. The morning peak was larger than the evening peak. The mass percentages of BC in PM2.5 and PM10 were 7.1% and 4.8%, respectively. The absorption coefficient of BC was calculated to be 44.4 Mm 1, which accounted for 11.1% of the total aerosol extinction. BC was mainly emitted from local sources in southwestern Jiaxing where BC concentrations were generally greater than 11 μg/m3 during the measurement period. Correlation analysis indicated that the main sources of BC were motor vehicle exhaust, and domestic and industrial combustion.

Lijuan Shen, Li Li, Sheng Lü, Xiaohan Zhang, Jie Liu, Junlin An, Guojun Zhang, Bo Wu, Fei Wang (2014) Characteristics of black carbon aerosol in Jiaxing, China during autumn 2013, PARTICUOLOGY.

Characterization of black carbon concentrations of haze with different intensities in Shanghai by a three-year field measurement

Abstract - Relationships between black carbon (BC) aerosols and haze with different intensities are analysed by using hourly averaged data of BC mass concentration (CBC) and meteorological parameters from April 2007 to March 2010 in Shanghai. The results show that the number of cumulative haze hours accounted for 59.6% of the all valid hours during the three-year test period, while slight, mild, moderate and severe haze contributed 64.4%, 24.3%, 8.8% and 2.5% of the haze hours, respectively. Seasonal haze hour percentages in all haze hours were 19.8, 19.5, 24.5 and 36.2 for spring, summer, fall and winter, respectively. The annual averaged CBC for haze hours and non-haze hours were 5.05 μg/m3 and 2.04 μg/m3 during the three test years, respectively. The observation results show a positive correlation between monthly averaged CBC and haze intensity, i.e., the higher the haze intensity, the higher the CBC. According to the test data, four ranges of CBC were introduced to show the relationships between BC aerosols and haze hour percentage, and found that the higher the CBC, the higher the percentage of haze hours in the corresponding range. When CBC was higher than 4.5 μg/m3, the haze hours accounted for 95.0% of the valid test hours of the three year time span, and it can be used as a sufficient condition of haze occurrence. In addition, a set of 96-h backward trajectories indicate that the air masses originated from north China were the main

non-local sources of haze in spring, fall and winter in Shanghai, and emissions from south regions of Shanghai were the primary non-local sources of the haze in summer.

Wang, H., Q. He, Y. Chen, & Y. Kang (2014) Characterization of black carbon concentrations of haze with different intensities in Shanghai by a three-year field measurement, ATMOSPHERIC ENVIRONMENT 99: 536-545.

Properties of light-absorbing aerosols in the Nagoya urban area, Japan, in August 2011 and January 2012: Contributions of brown carbon and lensing effect

Nakayama, T., Y. Ikeda, Y. Sawada, Y. Setoguchi, S. Ogawa, K. Kawana, M. Mochida, F. Ikemori, K. Matsumoto, & Y. Matsumi (2014) Properties of light-absorbing aerosols in the Nagoya urban area, Japan, in August 2011 and January 2012: Contributions of brown carbon and lensing effect, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Early View).

Abstract - The optical properties of aerosols at 405 and 781 nm were measured in an urban site in Nagoya, Japan, in August 2011 and in January 2012 using a photoacoustic spectrometer. Comparison of the absorption coefficient at 781 nm of aerosols that did and did not pass through a thermo-denuder showed that an increase in black carbon (BC) light absorption due to the coating of non-refractory materials (i.e., the lensing effect) was small (on average, 10%) in August and negligible in January. The effective density distributions for the particles that did and did not pass through the thermo-denuder, which were measured simultaneously in August, suggested that the majority of BC particles sampled had a minimal coating. The small lensing effect observed can be explained partly by assuming that a large portion of non-refractory materials was mixed externally with BC. The contribution of direct light absorption by organic matter (OM) that vaporized at temperatures below 300 C to the total light absorption at 405 nm was negligible in August, but those by OM that vaporized below 300 and 400 C averaged 11 and 17%, respectively, in January. The larger contribution of light-absorbing OM in January is likely due to the greater contribution of OM originating from the burning of biomass, including biofuel and agricultural residue, in Japan, northern China, or Siberia, during the winter

Wet deposition of black carbon at a remote site in the East China Sea

Abstract - Mass concentrations of black carbon (BC) in air (MBC) and rainwater (CBC) in the East China Sea were measured at Hedo on Okinawa Island, Japan, from April 2010 to March 2013. The monthly averaged MBC and CBC showed marked seasonal variations, being highest in spring (0.32 0.13 g m 3 and 92 76 g L 1, respectively) and lowest in summer (0.06 0.03 g m 3 and 8.0 4.1 g L 1, respectively). The high MBC and CBC in spring were associated with transport of air masses from the Asian continent by northwesterly winds. The BC wet deposition flux (FBC), estimated as the product of CBC and precipitation amount, also showed a distinct seasonal variation. The monthly average FBC during the four spring seasons (16.8 6.7 mg m 2 month 1) was about 3 times higher than the annual average FBC (5.5 9.9 mg m 2 month 1) owing to the high CBC and precipitation amount in spring. As a result, about 76% of the annual BC deposition occurred in spring on average. The FBC in spring is comparable to the average BC net flux in North China, indicating the importance of precipitation over the East China Sea as a sink of BC transported from North China. In summer, CBC values were correlated with MBC for rain events associated with local convective activity, as identified by the convective available potential energy. A one-dimensional thermodynamic model successfully explained the relation between CBC and MBC.

Mori, T., Y. Kondo, S. Ohata, N. Moteki, H. Matsui, N. Oshima, & A. Iwasaki (2014) Wet deposition of black carbon at a remote site in the East China Sea, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(17):10,485-10,498.

Black carbon and other light-absorbing particles in snow of central North America

Abstract - Vertical profiles of light-absorbing particles in seasonal snow were sampled from 67 North American sites. Over 500 snow samples and 55 soil samples from these sites were optically analyzed

for spectrally resolved visible light absorption. The optical measurements were used to estimate black carbon (BC) mixing ratios in snow (inline image), contributions to absorption by BC and non-BC particles, and the absorption Ångström exponent of particles in snow and local soil. Sites in Canada tended to have the lowest BC mixing ratios (typically ~5–35 ng g 1), with somewhat higher inline image in the Pacific Northwest (typically ~5–40 ng g 1) and Intramountain Northwest (typically 10–50 ng g 1). The Northern U.S. Plains sites were the dirtiest, with inline image typically ~15–70 ng g 1 and multiple sample layers with >100 ng g 1 BC in snow. Snow water samples were also chemically analyzed for standard anions, selected carbohydrates, and various elements. The chemical and optical data were input to a Positive Matrix Factorization analysis of the sources of particulate light absorption. These were soil, biomass/biofuel burning, and fossil fuel pollution. Comparable analyses have been conducted for the Arctic and North China, providing a broad, internally consistent data set. As in North China, soil is a significant contributor to snow particulate light absorption in the Great Plains. We also examine the concentrations and sources of snow particulate light absorption across a latitudinal transect from the northern U.S. Great Plains to Arctic Canada by combining the current data with our earlier Arctic survey.

Doherty, S. J., C. Dang, D. A. Hegg, R. Zhang, & S. G. Warren (2014) Black carbon and other light-absorbing particles in snow of central North America, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 199(22):12807-12831.

Black carbon radiative forcing over the Tibetan Plateau

Abstract - We estimate the snow albedo forcing and direct radiative forcing (DRF) of black carbon (BC) in the Tibetan Plateau using a global chemical transport model in conjunction with a stochastic snow model and a radiative transfer model. The annual mean BC snow albedo forcing is 2.9 W m 2 averaged over snow-covered plateau regions, which is a factor of 3 larger than the value over global land snowpack. BC-snow internal mixing increases the albedo forcing by 40–60% compared with external mixing, and coated BC increases the forcing by 30–50% compared with uncoated BC aggregates, whereas Koch snowflakes reduce the forcing by 20–40% relative to spherical snow grains. The annual BC DRF at the top of the atmosphere is 2.3 W m 2 with uncertainties of 70–85% in the plateau after scaling the modeled BC absorption optical depth to Aerosol Robotic Network observations. The BC forcings are attributed to emissions from different regions.

He, C., Q. Li1, K.-N. Liou, Y. Takano, Y. Gu, L. Qi1, Y. Mao, & L. R. Leung (2014) Black carbon radiative forcing over the Tibetan Plateau, GEOPHYSICAL RESEARCH LETTERS (Early View).

Using an explicit emission tagging method in global modeling of source-receptor relationships for black carbon in the Arctic: Variations, sources, and transport pathways

Abstract - We introduce an explicit emission tagging technique in the Community Atmosphere Model to quantify source-region-resolved characteristics of black carbon (BC), focusing on the Arctic. Explicit tagging of BC source regions without perturbing the emissions provides a physically consistent and computationally efficient approach to establish source-receptor relationships and transport pathways. Our analysis shows that the contributions of major source regions to the global BC burden are not proportional to the respective emissions due to strong region-dependent removal rates and lifetimes, while the contributions to BC direct radiative forcing show a near-linear dependence on their respective contributions to the burden. Arctic BC concentrations, deposition, and source contributions all have strong seasonal variations. Eastern Asia contributes the most to the wintertime Arctic BC burden, but has much less impact on lower-level concentrations and deposition. Northern Europe emissions are more important to both surface concentration and deposition in winter than in summer. The largest contribution to Arctic BC in the summer is from Northern Asia. Although local emissions contribute less than 10% to the annual mean BC burden and deposition within the Arctic, the per-emission efficiency is much higher than for non-Arctic sources. The interannual variability (1996–2005) due to meteorology is small in annual mean BC burden and radiative forcing but is significant in yearly seasonal means over the Arctic. When a slow aging treatment of BC is introduced, the increase of BC lifetime and burden is source dependent. Global BC forcing-per-burden efficiency also increases primarily due to changes in BC vertical distributions.

Wang1, H., P. J. Rasch, R. C. Easter, B. Singh, R. Zhang, P.-L. Ma, Y. Qian, S. J. Ghan, & N. Beagley (2014) Using an explicit emission tagging method in global modeling of source-receptor relationships for black carbon in the Arctic: Variations, sources, and transport pathways, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Early View).

Abundance, distribution, and isotopic composition of particulate black carbon in the northern Gulf of Mexico

Abstract - There exists increasing evidence supporting the important role of black carbon in global carbon cycles. Particulate black carbon (PBC) is allochthonous and has distinct reactivities compared to the bulk particulate organic carbon (tot-POC) in marine environments. However, the abundance, geochemical behavior of PBC and its importance in oceanic carbon budget remain poorly understood. Here we report the abundance, distribution, and stable isotopic signatures of BC derived from the chemo-thermal oxidation (CTO-375) method (BCCTO) in the Gulf of Mexico. Our results show that BCCTO abundance decreased from shelf to basin, and more than a half of riverine BCCTO could be removed over the shelf. Moreover, BCCTO is much more refractory compared to the tot-POC and has 13C values lower than those of BC-excluded POC. These results highlight the significance of PBC in marine carbon cycles and potentially suggest the need for a new end-member term in quantifying POC sources in the ocean.

Yang, W., & L. Guo (2014) Abundance, distribution, and isotopic composition of particulate black carbon in the northern Gulf of Mexico, GEOPHYSICAL RESEARCH LETTERS 41(21):7,619-7,625.

Global and regional climate impacts of black carbon and co-emitted species from the on-road diesel sector

Abstract - Diesel vehicles are a significant source of black carbon (BC) and ozone precursors, which are important contributors to climate warming, degrade air quality and harm human health. Reducing diesel emissions could mitigate near-term climate change with significant co-benefits. This study quantifies the global and regional climate impacts of BC and co-emitted short-lived climate forcers (SLCFs) from present-day on-road diesel vehicles, as well as future impacts following a current legislation emission scenario. Atmospheric concentrations are calculated by the chemical transport model OsloCTM2. The following radiative forcing (RF) and equilibrium surface temperature responses are estimated. For year 2010 on-road diesel emissions we estimate a global-mean direct RF from BC of 44 m W/m2 and an equilibrium surface temperature response of 59 mK, including the impact of BC deposition on snow. Accounting for cooling and warming impacts of co-emitted SLCFs results in a net global-mean RF and warming of 28 mW/m2 and 48 mK, respectively. Using the concept of Regional Temperature change Potential (RTP), we find significant geographical differences in the responses to regional emissions. Accounting for the vertical sensitivities of the forcing/response relation amplifies these differences. In terms of individual source regions, emissions in Europe give the largest regional contribution to equilibrium warming caused by year 2010 on-road diesel BC, while Russia is most important for Arctic warming per unit emission. The largest contribution to warming caused by the year 2050 on-road diesel sector is from emissions in South Asia, followed by East Asia and the Middle East. Hence, in regions where current legislation is not sufficient to outweigh the expected growth in activity, accelerated policy implementation is important for further future mitigation.

Lund, M. T., T. K. Berntsen, C. Heyes, Z. Klimont, & B. H. Samset (2014) Global and regional climate impacts of black carbon and co-emitted species from the on-road diesel sector, ATMOSPHERIC ENVIRONMENT 98:50-58.

Implications of multiple scattering on the assessment of black carbon aerosol radiative forcing

Abstract - The effects of radiative coupling between scattering and absorbing aerosols, in an external mixture, on the aerosol radiative forcing (ARF) due to black carbon (BC), its sensitivity to the composite aerosol loading and composition, and surface reflectance are investigated using radiative transfer model simulations. The ARF due to BC is found to depend significantly on the optical properties of the 'neighboring' (non-BC) aerosol species. The scattering due to these species

significantly increases the top of the atmospheric warming due to black carbon aerosols, and significant changes in the radiative forcing efficiency of BC. This is especially significant over dark surfaces (such as oceans), despite the ARF due to BC being higher over snow and land-surfaces. The spatial heterogeneity of this effect (coupling or multiple scattering by neighboring aerosol species) imposes large uncertainty in the estimation ARF due to BC aerosols, especially over the oceans.

Vijayakumar S. Nair, S. Suresh Babu, K. Krishna Moorthy, S.K. Satheesh (2014) Implications of multiple scattering on the assessment of black carbon aerosol radiative forcing, JOURNAL OF QUANTITATIVE SPECTROSCOPY AND RADIATIVE TRANSFER 148:134-140.

Foliar rinse study of atmospheric black carbon deposition to leaves of konara oak (Quercus serrata) stands

Abstract - Dry deposition of Black Carbon (BC) to the actual leaves of konara oak (Quercus serrata) was evaluated in a foliar rinse method in an experimental forest in the suburbs of Tokyo, Japan in order to explore deposition levels and vertical profile within the forest. At three heights of the forest of 20 m height, 20 m, 15 m, and 6 m or 4 m, leaves were sampled on a weekly basis for a couple of months in 2011 and 2012 and subjected to rinsing with water and chloroform. The BC in the rinse solution was collected on a quartz fiber filter and determined by spectrophotometry. The BC mass deposited to leaves increased with height and this profile pattern was generally maintained in the study period. The specific BC mass deposited to leaves showed considerable fluctuations with time, but the deposited BC increased rapidly with time in the bud flushing stage, then attained to a plateau, and began to decrease as the defoliation advanced. The plateau is a result of a simple accumulation with time and occasional removal due to rainfall and strong winds. The maximum BC mass deposited to leaves per leaf surface unit area occurred in June where the level was 10–15 mg-BC m 2. The rate of BC mass deposited to leaves at the time of leaves growing was determined to be 0.237 and 0.277 mg-BC m 2 day 1 for measurements in 2011 and 2012, respectively. On the basis of the observed BC mass deposited to the leaves, BC mass deposited to leaves per forest floor unit area estimated with LAI showed a strong seasonality. The BC mass deposited to leaves per forest floor unit area was compared to the deposition flux from the atmosphere to the forest canopy, which would be interpreted as indicating that 30% of atmospheric BC deposition to the canopy was retained on the leaves in time of leaves growing.

Hara, H., T. Kashiwakura, K. Kitayama, S. D. Bellingrath-Kimura, T. Yoshida, M. Takayanagi, S. Yamagata, N. Murao, H. Okouchi, & H. Ogata (2014) Foliar rinse study of atmospheric black carbon deposition to leaves of konara oak (Quercus serrata) stands, ATMOSPHERIC ENVIRONMENT 97:511-518.

Aerosol black carbon characteristics over Central India: Temporal variation and its dependence on mixed layer height

Abstract - In a first of its kind study over the Indian region, concurrent and extensive measurements of black carbon (BC) concentration and atmospheric boundary layer parameters are used to quantify the role of atmospheric boundary layer in producing temporal changes in BC. During this study, 18 months (2011–12) data of continuous measurements of BC aerosols, made over a semi-urban location, Nagpur, in Central India are used along with concurrent measurements of vertical profiles of atmospheric thermodynamics, made using weekly ascents of GPS aided Radiosonde for a period of 1 year. From the balloon data, mixed layer heights and ventilation coefficients are estimated, and the monthly and seasonal changes in BC mass concentration are examined in the light of the boundary layer changes. Seasonally, the BC mass concentration was highest (~ 4573 1293 ng m 3) in winter (December–February), and lowest (~ 1588 897 ng m 3) in monsoon (June–September), while remained moderate (~ 3137 1446 ng m 3) in pre-monsoon (March–May), and post-monsoon (~ 3634 813 ng m 3) (October–November) seasons. During the dry seasons, when the rainfall is scanty or insignificantly small, the seasonal variations in BC concentrations have a strong inverse relationship with mixed layer height and ventilation coefficient. However, the lowest BC concentrations do not occur during the season when the mixed layer height (MLH) is highest or the ventilation coefficient is the highest; rather it occurs when the rainfall is strong (during summer monsoon season) and airmass changes to primarily of marine origin.

Kompalli, S. K., S. S. Babu, K. K. Moorthy, M. R. Manoj, N. V. P. K. Kumar, K. H. B. Shaeb, & A. K. Joshi (2014) Aerosol black carbon characteristics over Central India: Temporal variation and its dependence on mixed layer height, ATMOSPHERIC RESEARCH 147–148:27-37.

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HYDROFLUOROCARBONS & ALTERNATIVES

China's hydrofluorocarbon challenge

Abstract - China should take more active participation in a prospective agreement on the global phase-down of hydrofluorocarbons.

Zhang, J. & C. Wang (2014) China's hydrofluorocarbon challenge, NATURE CLIMATE CHANGE 4:943–945.

Global emissions of refrigerants HCFC-22 and HFC-134a: Unforeseen seasonal contributions

Abstract - Recent research on the agricultural impacts of climate change has primarily focused on the roles of temperature and precipitation. These studies show that India has already been negatively affected by recent climate trends. However, anthropogenic climate changes are a result of both global emissions of long-lived greenhouse gases (LLGHGs) and other short-lived climate pollutants (SLCPs). Two potent SLCPs, tropospheric ozone and black carbon, have direct effects on crop yields beyond their indirect effects through climate; emissions of black carbon and ozone precursors have risen dramatically in India over the past three decades. Here, to our knowledge for the first time, we present results of the combined effects of climate change and the direct effects of SLCPs on wheat and rice yields in India from 1980 to 2010. Our statistical model suggests that, averaged over India, yields in 2010 were up to 36% lower for wheat than they otherwise would have been, absent climate and pollutant emissions trends, with some densely populated states experiencing 50% relative yield losses. [Our point estimates for rice (20%) are similarly large, but not statistically significant.] Upper-bound estimates suggest that an overwhelming fraction (90%) of these losses is due to the direct effects of SLCPs. Gains from addressing regional air pollution could thus counter expected future yield losses resulting from direct climate change effects of LLGHGs.

Xiang, B., P. K. Patra, S. A. Montzka, S. M. Miller, J. W. Elkins, F. L. Moore, E. L. Atlas, B. R. Miller, R. F. Weiss, R. G. Prinn, & S. C. Wofsy (2014) Global emissions of refrigerants HCFC-22 and HFC-134a: Unforeseen seasonal contributions, PNAS (Early View).

System performance of R-1234yf refrigerant in air-conditioning and heat pump system – An overview of current status

Abstract - In this study, an overview of the system performance of R-1234yf in association with R-134a is carried out. Based on the existing researches, it is found that the COP and heat capacity of R-134a system may suffer from direct drop-in replacement of R-1234yf. The deterioration is around 0–27% depending on the operational conditions. With the introduction of internal heat exchanger, ejector, expander, or adjustment of the thermal expansion valve, the deterioration can be relieved, and a comparable performance becomes likely. For the heat transfer performance in the evaporator, R-1234yf is almost comparable with that of R-134a. However, the performance in the condenser is inferior to R-134a. The phenomenon may be quite severe for a water cooled condenser since the dominant thermal resistance may fall in the refrigerant side. The volumetric efficiency of R-1234yf system is slightly lower than that of R-134a due to higher frictional drop of R-1234yf. For the same thermal expansion valve for controlling the suction superheat, it appears that higher suction superheat may occur for R-1234yf refrigerant. Hence further adjustment of spring in the valve is required for soft optimization.

Chi-Chuan Wang (2014) System performance of R-1234yf refrigerant in air-conditioning and heat pump system – An overview of current status, APPLIED THERMAL ENGINEERING 73(2):1412-1420.

Experimental evaluation of a R134a/CO2 cascade refrigeration plant

Abstract - We present the experimental evaluation of a R134a/CO2 cascade refrigeration plant designed for low evaporation temperature in commercial refrigeration applications. The test bench incorporates two single-stage vapour compression cycles driven by semi hermetic compressors coupled thermally through two brazed plate cascade heat exchangers working in parallel and controlled by electronic expansion valves. The experimental evaluation (45 steady-states) covers evaporating temperatures from 40 to 30 C and condensing from 30 to 50 C. In each steady-state, we conducted a sweep of the condensing temperature of the low temperature cycle with speed variation of the high temperature compressor. Here, the energy performance of the plant is analysed, focussing on the compressors' performance, temperature difference in the cascade heat exchanger, cooling capacity, COP and compressors discharge temperatures.

Carlos Sanz-Kock, Rodrigo Llopis, Daniel Sánchez, Ramón Cabello, Enrique Torrella (2014) Experimental evaluation of a R134a/CO2 cascade refrigeration plant, APPLIED THERMAL ENGINEERING 73(1):41-50.

Inventory and mitigation opportunities for HFC-134a emissions from nonprofessional automotive service

Abstract - Many vehicle owners in the United States recharge their vehicles' air conditioning systems with small containers of hydrofluorocarbon-134a (HFC-134a, CH2FCF3), at a frequency estimated to be once every year on average. Such nonprofessional service produces immediate emissions of this potent greenhouse gas during service and from the residual heel in partially used containers. The nonprofessional operations are also associated with increased delayed refrigerant emissions that occur because owners are less likely to repair leaks than professional technicians. In California, an estimated 1.3 million nonprofessional service operations performed each year generate 0.27 0.07 million metric ton CO2 equivalent (MMTCO2e) of immediate emissions and 0.54 0.08 MMTCO2e of delayed emissions, using a Global Warming Potential of 1300 for HFC-134a. The immediate emissions can be largely mitigated by a regulation that requires self-sealing valves and improved labeling instructions on the containers, a deposit-return-recycling program for the containers, and a consumer education program. If 95% of the used containers were to be returned by consumers for recycling of the container heel, the annual immediate emissions would be reduced by 0.26 0.07 MMTCO2e. In the United States, an estimated 24 million nonprofessional service operations are performed each year, generating 5.1 1.4 MMTCO2e of immediate emissions and 10.4 1.5 MMTCO2e of delayed emissions. Mitigation measures equivalent to the California regulation would reduce nationwide immediate emissions by 4.9 1.4 MMTCO2e, if 95% of the used cans were returned for recycling. These business-as-usual emissions and mitigation potentials are projected to stay approximately constant until around 2022, and remain at significant levels into the 2030s.

Zhan, T., W. Potts, J. F. Collins, & J. Austin (2014) Inventory and mitigation opportunities for HFC-134a emissions from nonprofessional automotive service, ATMOSPHERIC ENVIRONMENT 99:17-23.

Analysis of diurnal variability of atmospheric halocarbons and CFC replacements to imply emission strength and sources at an urban site of Lukang in central Taiwan

Abstract - Hourly atmospheric measurements of halocarbons and chlorofluorocarbon (CFC) replacements were conducted at an urban site of Lukang, Changhua, in central Taiwan from May to August, 2013. The temporal distribution of different groups of halocarbons in the Lukang urban atmosphere, including chlorofluorocarbons (CFCs), Chlorodifluoromethane (HCFC-22), Bromochlorodifluoromethane (Halon-1211), and other chlorinated compounds, is presented and discussed. The concentrations (mixing ratios) of HCFC-22, Dichlorodifluoromethane (CFC-12), Halon-1211, Trichlorofluoromethane (CFC-11), Dichloromethane (CH2Cl2), and Trichloroethylene (TCE) were enhanced with respect to the local background levels; the atmospheric mixing ratio of carbon tetrachloride (CCl4) was slightly higher than its local background level; on the other hand, 1,1,2-Trichlorotrifluoroethane (CFC-113) was relatively uniform and not very different from background atmospheric level in non-urban areas. Among these compounds, HCFC-22, Halon-1211 and the

halogenated compounds, CH2Cl2 and TCE, used as solvents were strongly enhanced. The average mixing ratio of Halon-1211 was higher than the local background of ~4.5 ppt by ~60% although Halon-1211 production had been phased out by 1996.

Hourly average mixing ratios of halocarbons (HCFC-22, CFC-12, Halon-1211, CFC-11, CH2Cl2, and TCE) illustrated a distinct diurnal cycle characterized with a pattern of elevated mixing ratio and large mixing ratio variability amplitude at night relative to that in daytime. Although emission sources of these halocarbons were complex, hourly average mixing ratios for most of these high variability halocarbons peaked at ~5:00 AM when the hourly average wind speed reached the minimum value of the day; by contrast, the hourly average mixing ratio of CO peaked at ~8:30 AM when the ambient atmospheric wind condition was strongly influenced by sea breezes during the traffic rush hours. This phenomenon revealed that meteorological factors predominated the distribution of halocarbon mixing ratio in the urban atmosphere and the traffic emission of CFC-12 derived from old vehicles manufactured before 1994 was insignificant to the CFC-12 mixing ratio in the urban atmosphere. The meteorological condition of nighttime atmospheric temperature inversion and low wind speed facilitated the accumulation of terrestrial airborne pollutants near the ground; consequently the hourly average mixing ratios at night were higher than those in daytime by up to ~2% (CFC-11), ~7% (CFC-12), ~75% (HCFC-22), ~72% (Halon-1211), ~280% (CH2Cl2), and ~155% (TCE).

Lee, B.-S., C.-B. Chiou, & C.-Y. Lin (2014) Analysis of diurnal variability of atmospheric halocarbons and CFC replacements to imply emission strength and sources at an urban site of Lukang in central Taiwan, ATMOSPHERIC ENVIRONMENT 99:112-123.

HFC-134a Emissions from Mobile Air Conditioning in China from 1995 to 2030

Abstract - Since 1995, 1,1,1,2-tetrafluoroethane (CH2FCF3, HFC-134a) has become the most important substitute of CFC-12 in mobile air conditioning (MAC) in China and MAC sector has dominated all the emissions of HFC-134a. In this study, we developed an accurate, updated and county-level inventory of the HFC-134a emissions from MAC in China for the period of 1995-2030 with an improved bottom-up method. Our estimation indicated that the total HFC-134a emissions kept growing at increase rates of ~ 100% per year for 1995-2000 and ~34% per year for 2001–2010. In 2010, HFC-134a emissions from MAC in China reached 16.7 Gg (10.5–22.7 Gg at 95% confidential interval), equivalent to 21.7 Tg CO2 (CO2-eq). Furthermore, the emissions in China estimated in this study accounted for 9.8% of global HFC-134a emissions and 29.0% of total emissions from Non-Annex_I countries in 2010. Due to the more advanced social-economic conditions and more intensive ownership of automobiles, greater HFC-134a were observed to come from big cities in East China. Under a Business-as-usual (BAU) Scenario, projected emissions will grow to 89.4 (57.9–123.9) Gg (about 75.3–161.1 Tg CO2-eq) in 2030, but under an Alternative Scenario, 88.6% of the projected emissions under BAU scenario could be curbed. Our estimation demonstrates huge emission mitigation potential of HFC-134a in China's MAC sector.

Shenshen Su, Xuekun Fang, Li Li, Jing Wu, Jianbo Zhang, Weiguang Xu, Jianxin Hu (2014) HFC-134a Emissions from Mobile Air Conditioning in China from 1995 to 2030, ATMOSPHERIC ENVIRONMENT (In Press).

Performance test of residential heat pump after partial optimization using low GWP refrigerants

Abstract - The present study aimed to improve the performance of the residential heat pump using R-32 and L-41b as a HFO blend after partial optimization by modifying heat exchanger and compressor discharge volume as well as providing the drop-in test data using low GWP refrigerants. Cooling and heating capacities, COP, discharge temperature, pressure drop of evaporator and condenser of the residential heat pump system were measured in case of drop-in test and test after partial optimization. Optimal refrigerant charge for R-32 and L-41b systems was less by 18–25% than that of R-410A system. Capacities of R-32 and L-41b systems through the drop-in test showed 105% and 89–94% of those of R-410A system respectively, while the COP of R-32 and L-41b systems showed 99–101% and 104–105% of those of R-410A systems, respectively. Discharge temperatures of R-32 system showed

up to 94.7 C, while those of L-41b system showed up to 86.4 C through the drop-in test. Cooling and heating capacities of R-32 and L-41b systems after partial optimization showed 99% and 101% of those of the R-410A system. Discharge temperatures of R-32 and L-41b systems after partial optimization were 81.8 C and 85.2 C under cooling standard mode, while they were 81.7 C and 80.2 C under heating standard mode. Pressure drops of heat exchanger by using L-41b after partial optimization were lower by 8% under cooling mode and 11% under heating mode for condenser and by 21% under cooling standard mode and 7% under heating standard mode for evaporator than those in case of drop-in test.

In, S., K. Cho, B. Lim, H. Kim, B. Youn (2014) Performance test of residential heat pump after partial optimization using low GWP refrigerants, Applied Thermal Engineering 72(2):315-322.

Experimental Investigation of the Effect of Condenser Subcooling in R134a and R1234yf Air-Conditioning Systems With and Without Internal Heat Exchanger

Abstract - This paper presents an experimental study about the effect of condenser subcooling on the performance of an air conditioning system operating with R134a and R1234yf, under the same operating conditions. For both refrigerants, it has been shown that the COP undergoes a maximum as a consequence of the trade-off between increasing refrigerating effect and increasing specific compression work. At a given operating condition, the system COP increased up to 18% for R1234yf and 9% for R134a. These results confirmed the trends obtained from a previous theoretical analysis, demonstrating that a system operating with R1234yf can benefit more from the condenser subcooling than that with R134a. The experimental results also showed that the presence of an internal heat exchanger significantly reduces the COP increase due to condenser subcooling, since both improvements compete towards reducing the throttling losses. Besides the interference between IHX and condenser subcooling, the use of both simultaneously still yields a more efficient air conditioning system, especially for R1234yf.

Pottker, G., P. Hrnjak (2014) Experimental Investigation of the Effect of Condenser Subcooling in R134a and R1234yf Air-Conditioning Systems With and Without Internal Heat Exchanger, International Journal of Refrigeration (In Press).

Flow boiling characteristics of R-245fa in a minichannel at medium saturation temperatures

Abstract - This paper presents new experimental results concerning thermohydraulic characteristics of flow boiling at medium saturation temperatures. The experimental results were obtained in a horizontal 3.0 mm inner tube diameter with R-245fa as working fluid. The mass velocity ranged from 100 to 1500 image s, the heat flux from image to image, the saturation temperature from 60 C to 80 C and the vapor quality from 0 to 1. Four flow patterns are likely to appear in these conditions: intermittent flow, annular flow, dry-out flow and mist flow. Heat transfer coefficients were measured and parametric analyses were performed on the effect of heat flux, mass velocity and saturation temperature on the local heat transfer coefficient. At 60 C and 80 C, the heat transfer coefficient is independent from vapor quality and mass velocity during intermittent flow whereas it is sensitive to heat flux. In annular flow, the heat transfer coefficient increases with increasing vapor quality and/or mass velocity. As a result, nucleate and convective boiling are both present. The pre-dryout database of 3070 data points is compared against several predictive methods from the literature. These comparisons are an extrapolation to test the validity of the prediction methods at medium saturation temperature in minichannels.

Charnay, R., R. Revellin, & J. Bonjour (2014) Flow boiling characteristics of R-245fa in a minichannel at medium saturation temperatures, Experimental Thermal and Fluid Science 59:184-194.

Performance analysis of a rooftop, air-to-air heat pump working with CO_2

Abstract - The air-conditioning sector for large buildings and shopping centers is developing a growing interest in rooftop heat pumps due to their easy installation. Instead of the application of

HFC refrigerants, carbon dioxide (CO2) could be an interesting perspective in this sector for environmental reasons. This work presents new performance data of an air-to-air heat pump roof-top system working with a trans-critical carbon dioxide cycle during the heating season. In particular, the experimental results showed how the heating power and the coefficient of performance are affected by the air temperature at the inlet of the gas cooler and by part load working conditions. A thermodynamic analysis pointed out the direct and indirect effects of fans speed and air flow temperatures on the performance, defining a performance map and the optimal range of application of such systems.

Calabrese, N., R. Mastrullo, A. W. Mauro, P. Rovella, & M. Tammaro (2014) Performance analysis of a rooftop, air-to-air heat pump working with CO_2, Applied Thermal Engineering (In Press).

Condensation in two phase and desuperheating zone for R1234ze(E), R134a and R32 in horizontal smooth tubes

Abstract - Condensation is usually assumed to begin when the bulk enthalpy reaches the saturated vapor enthalpy, which leads to discontinuity of heat transfer coefficient calculation in modeling. This paper addresses the discontinuity by showing the presence of condensation in desuperheating region when the wall temperature decreases below the saturation temperature at any operating condition. The experiments have been conducted with R134a, R1234ze(E) and R32 for mass fluxes of 100-300 kgm-2s-1, saturation temperatures of 30 C-500C and from x=0.05 to superheat of 50 C in a horizontal smooth tube with 6.1 mm inner diameter. R134a is observed to have approximately 10 % higher and 20% lower HTC compared to R1234ze(E) and R32 respectively. Cavallini correlation predicted the data within an accuracy of 12% while Kondo-Hrnjak correlation predicted HTC for condensation in de-superheating zone within accuracy of 23%.

Agarwal, R., & P. Hrnjak (2014) Condensation in two phase and desuperheating zone for R1234ze(E), R134a and R32 in horizontal smooth tubes, International Journal of Refrigeration (In Press).

A novel low-temperature absorption–compression cascade refrigeration system

Abstract - This paper presents a novel absorption–compression cascade refrigeration system, which can reach an evaporating temperature of 170 C. In the cascade system, the refrigerant of compression subsystem (CS) is subcooled by the refrigerant of low-grade heat driven absorption subsystem (AS) to reduce the electric power consumption. Theoretical and experimental investigations were carried out over the CS evaporating temperature ranging from 100 to 170 C and operating parameters were given. At the CS evaporating temperature of 170 C, when AS provided a low-grade cooling capacity of 164.8 W to CS, a decrease of 2.5 C in CS evaporating temperature or an increase of 32.3 W in high-grade cooling capacity of CS were observed. Meanwhile, in CS, the discharge temperature and pressure decreased, while the suction pressure increased. These beneficial results not only verified the feasibility of the system, but also revealed the application potential of the system in the future.

Xu, Y., F. Chen, Q. Wang, X. Han, D. Li, & G. Chen (2014) A novel low-temperature absorption–compression cascade refrigeration system, Applied Thermal Engineering (In Press).

Drop-in energy performance evaluation of R1234yf and R1234ze(E) in a vapor compression system as R134a replacements

Abstract - This paper presents an energy performance evaluation of two low-GWP refrigerants, R1234yf and R1234ze(E), as drop-in replacements for R134a. Tests are carried out in a monitored vapor compression system combining different values of evaporation and condensation temperature, and without/with the adoption of an internal heat exchanger. The parameters analyzed are volumetric efficiency, cooling capacity and COP and they are presented taking R134a as baseline. Results show that without IHX the average volumetric efficiency for R1234yf and R1234ze is 4% and 5% lower compared with R134a. The cooling capacity obtained with R1234yf and R1234ze is reduced, with an average difference of 9% and 30% without IHX. Also, COP values are about 7% lower for R1234yf and

6% lower for R1234ze than those obtained using R134a. Finally, the use of an internal heat exchanger reduces the COP differences for both replacements.

Mota-Babiloni, A., J. Navarro-Esbrí, Á. Barragán, F. Molés, & B. Peris (2014) Drop-in energy performance evaluation of R1234yf and R1234ze(E) in a vapor compression system as R134a replacements, APPLIED THERMAL ENGINEERING 71(1):259-265.

Experimental Assessment of residential split type air-conditioning systems using alternative refrigerants to R-22 at high ambient temperatures

Abstract - Steady state performance of residential air conditioning systems using R22 and alternatives R290, R407C, R410A, at high ambient temperatures, have been investigated experimentally. System performance parameters such as optimum refrigerant charge, coefficient of performance, cooling capacity, power consumption, pressure ratio, power per ton of refrigeration and TEWI environmental factor have been determined. All refrigerants were tested in the cooling mode operation under high ambient air temperatures, up to 55 C, to determine their suitability. Two split type air conditioner of 1 and 2 TR capacities were used. A psychrometric test facility was constructed consisting of a conditioned cool compartment and an environmental duct serving the condenser. Air inside the conditioned compartment was maintained at 25 C dry bulb and 19 C wet bulb for all tests. In the environmental duct, the ambient air temperature was varied from 35 C to 55 C in 5 C increments. The study showed that R290 is the better candidate to replace R22 under high ambient air temperatures. It has lower TEWI values and a better coefficient of performance than the other refrigerants tested. It is suitable as a drop-in refrigerant. R407C has the closest performance to R22, followed by R410A.

Joudi, K. A., & Q. R. Al-Amir (2014) Experimental Assessment of residential split type air-conditioning systems using alternative refrigerants to R-22 at high ambient temperatures, ENERGY CONVERSION AND MANAGEMENT 86:496-506.

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TROPOSPHERIC OZONE

Reforestation as a novel abatement and compliance measure for ground-level ozone

Abstract - High ambient ozone (O3) concentrations are a widespread and persistent problem globally. Although studies have documented the role of forests in removing O3 and one of its precursors, nitrogen dioxide (NO2), the cost effectiveness of using peri-urban reforestation for O3 abatement purposes has not been examined. We develop a methodology that uses available air quality and meteorological data and simplified forest structure growth-mortality and dry deposition models to assess the performance of reforestation for O3 precursor abatement. We apply this methodology to identify the cost-effective design for a hypothetical 405-ha, peri-urban reforestation project in the Houston–Galveston–Brazoria O3 nonattainment area in Texas. The project would remove an estimated 310 tons of (t) O3 and 58 t NO2 total over 30 y. Given its location in a nitrogen oxide (NOx)-limited area, and using the range of Houston area O3 production efficiencies to convert forest O3 removal to its NOx equivalent, this is equivalent to 127–209 t of the regulated NOx. The cost of reforestation per ton of NOx abated compares favorably to that of additional conventional controls if no land costs are incurred, especially if carbon offsets are generated. Purchasing agricultural lands for reforestation removes this cost advantage, but this problem could be overcome through cost-share opportunities that exist due to the public and conservation benefits of reforestation. Our findings suggest that peri-urban reforestation should be considered in O3 control efforts in Houston, other US nonattainment areas, and areas with O3 pollution problems in other countries, wherever O3 formation is predominantly NOx limited.

Kroeger, T., F. J. Escobedo, J. L. Hernandez, S. Varela, Sonia Delphin, Jonathan R. B. Fisher, & Janice Waldron (2014) Reforestation as a novel abatement and compliance measure for ground-level ozone, PNAS 111(40):E4204-E4213.

Effects of trans-Eurasian transport of air pollutants on surface ozone concentrations over Western China

Abstract - Due to a lack of industrialization in Western China, surface air there was, until recently, believed to be relatively unpolluted. However, recent measurements and modeling studies have found high levels of ozone (O3) there. Based on the state-of-the-science global chemical transport model MOZART-4, we identify the origin, pathway, and mechanism of trans-Eurasian transport of air pollutants to Western China in 2000. MOZART-4 generally simulates well the observed surface O3 over inland areas of China. Simulations find surface ozone concentrations over Western China on average to be about 10 ppbv higher than Eastern China. Using sensitivity studies, we find that anthropogenic emissions from all Eurasian regions except China contribute 10–15 ppbv surface O3 over Western China, superimposed upon a 35–40 ppbv natural background. Transport from European anthropogenic sources to Northwestern China results in 2–6 ppbv O3 enhancements in spring and summer. Indian anthropogenic sources strongly influence O3 over the Tibetan Plateau during the summer monsoon. Transport of O3 originating from emissions in the Middle East occasionally reach Western China and increase surface ozone there by about 1–4 ppbv. These influences are of similar magnitude as trans-Pacific and transatlantic transport of O3 and its precursors, indicating the significance of trans-Eurasian ozone transport in hemispheric transport of air pollution. Our study further indicates that mitigation of anthropogenic emissions from Europe, the Indian subcontinent, and the Middle East could benefit public health and agricultural productivity in Western China.

Li, X., J. Liu, D. L. Mauzerall, L. K. Emmons, S. Walters, L. W. Horowitz, & S. Tao (2014) Effects of trans-Eurasian transport of air pollutants on surface ozone concentrations over Western China, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(21):12,338-12,354.

Atmospheric photochemical reactivity and ozone production at two sites in Hong Kong: Application of a Master Chemical Mechanism–photochemical box model

Abstract - A photochemical box model incorporating the Master Chemical Mechanism (v3.2), constrained with a full suite of measurements, was developed to investigate the photochemical reactivity of volatile organic compounds at a semirural site (Mount Tai Mo Shan (TMS)) and an urban site (Tsuen Wan (TW)) in Hong Kong. The levels of ozone (O3) and its precursors, and the magnitudes of the reactivity of O3 precursors, revealed significant differences in the photochemistry at the two sites. Simulated peak hydroperoxyl radical (HO2) mixing ratios were similar at TW and TMS ($p = 0.05$), while the simulated hydroxyl radical (OH) mixing ratios were much higher at TW ($p < 0.05$), suggesting different cycling processes between OH and HO2 at the two sites. The higher OH at TW was due to high-NO mixing ratios, which shifted the HOx (OH + HO2) balance toward OH by the propagation of HO2 and alkyl peroxy radicals (RO2) with NO. HOx production was dominated by O3 photolysis at TMS, but at TW, both HCHO and O3 photolyses were found to be major contributors. By contrast, radical-radical reactions governed HOx radical losses at TMS, while at TW, the OH + NO2 reaction was found to dominate in the morning and the radical-radical reactions at noon. Overall, the conversion of NO to NO2 by HO2 dictated the O3 production at the two sites, while O3 destruction was dominated by the OH + NO2 reaction at TW, and at TMS, O3 photolysis and the O3 + HO2 reaction were the major mechanisms. The longer OH chain length at TMS indicated that more O3 was produced for each radical that was generated at this site.

Ling, Z. H., H. Guo, S. H. M. Lam, S. M. Saunders, & T. Wang (2014) Atmospheric photochemical reactivity and ozone production at two sites in Hong Kong: Application of a Master Chemical Mechanism–photochemical box model, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(17):10,567-10,582.

Measurement of boundary layer ozone concentrations on-board a Skywalker unmanned aerial vehicle

Abstract - This study demonstrates novel measurements of in situ ozone (O3) concentrations and thermodynamics sampled on-board an instrumented Skywalker Unmanned Aerial Vehicle (UAV). Small spatial and temporal gradients were observed over a localized region, which nearby ground-based in situ measurements lack the ability to resolve. It was found that the UAV-measured O3 concentrations provided a useful additional indicator of O3 variability at the sub-urban scale. The ability to sample subtle variability over a localized area highlights the important and novel capabilities of UAVs to rapidly characterize local area micrometeorology and chemistry.

Illingworth, S., G. Allen, C. Percival, P. Hollingsworth, M. Gallagher, H. Ricketts, H. Hayes, P. adosz, D. Crawley, & G. Roberts (2014) Measurement of boundary layer ozone concentrations on-board a Skywalker unmanned aerial vehicle, ATMOSPHERIC SCIENCE LETTERS 15(4):252-258.

Ozone — the persistent menace: interactions with the N cycle and climate change

Abstract - Tropospheric ozone is involved in a complex web of interactions with other atmospheric gases and particles, and through ecosystem interactions with the N-cycle and climate change. Ozone itself is a greenhouse gas, causing warming, and reductions in biomass and carbon sequestration caused by ozone provide a further indirect warming effect. Ozone also has cooling effects, however, for example, through impacts on aerosols and diffuse radiation.

Ecosystems are both a source of ozone precursors (especially of hydrocarbons, but also nitrogen oxides), and a sink through deposition processes. The interactions with vegetation, atmospheric chemistry and aerosols are complex, and only partially understood. Levels and patterns of global exposure to ozone may change dramatically over the next 50 years, impacting global warming, air quality, global food production and ecosystem function.

Simpson, D., A. Arneth, G. Mills, S. Solberg, & J. Uddling (2014) Ozone — the persistent menace: interactions with the N cycle and climate change, CURRENT OPINION IN ENVIRONMENTAL SUSTAINABILITY 9–10:9-19.

Long-term surface ozone variability at Mt. Cimone WMO/GAW global station (2165 m a.s.l., Italy)

Abstract - The Mediterranean basin represents a hot spot area for short-term O3 distribution and anthropogenic contributions to it. This is why we analysed in this work the surface O3 variability observed at Mt. Cimone WMO/GAW global station (CMN, 44 12' N, 10 42' E, 2165 m a.s.l., Italy) from 1991 to 2011. The measurements performed at this mountain observatory represent the longest surface O3 record at a baseline site in the Mediterranean basin.

Monthly O3 averages at CMN show a typical seasonal cycle characterised by a winter minimum and a spring – summer maxima. The shape of the mean annual variation of O3 is well comparable with those observed at other four baseline sites in the Alps and in the Mediterranean region: Jungfraujoch – Swiss Alps, Sonnblick – Austrian Alps, Mt. Krvavec– Slovenia and Giordan Lightouse – Island of Gozo, Malta. In general, O3 levels at CMN show higher values during warm months, which is likely to be related both to vertical transport of polluted air-masses at regional and continental scales and to enhanced photochemistry.

Here, we also investigate the influence of specific atmospheric processes (i.e. the occurrence of heat-waves, North Atlantic Oscillation, thermal transport of air-masses from the regional PBL and stratospheric intrusions) in affecting O3 variability at CMN.

Overall, a significant positive (95% confidence level) linear trend in monthly O3 mole fraction was observed over the period 1991–2011 (0.21 0.10 nmol/mol yr 1) while no trend (-0.02 0.12 nmol/mol yr 1) was detected for the 1996–2011, when measurements were carried out by an homogeneous experimental set-up. On a seasonal basis, a positive trend has been observed for 1996–2011 (0.34 0.32 nmol/mol yr 1) only for spring. Significant decreases of the seasonal O3 growth-

rates have been detected at CMN during 1991–2011 from winter to spring and only for summer during 1996–2011.

Cristofanelli, P., H.-E. Scheel, M. Steinbacher, M. Saliba, F. Azzopardi, R. Ellul, M. Fröhlich, L. Tositti, E. Brattich, M. Maione, F. Calzolari, R. Duchi, T.C. Landi, A. Marinoni, & P. Bonasoni (2014) Long-term surface ozone variability at Mt. Cimone WMO/GAW global station (2165 m a.s.l., Italy), ATMOSPHERIC ENVIRONMENT 101:23-33.

Deviations from the O3–NO–NO2 photo-stationary state in Delhi

Abstract - A network of air quality and weather monitoring stations was set-up across Delhi, India, under the System of Air quality Forecasting And Research (SAFAR) project. The objective of this network was to enable better understanding of air quality in terms of atmospheric chemistry, emissions and forecasting in Delhi, one of the largest metropolises in the world. In this study, we focus on the O3–NO–NO2-triad Photo Stationary State (PSS), and investigate site-specific deviations in the Leighton Ratio ( ) during a short period in 2012 (1–31 December). Large variations were observed in the NO (<1 ppbv to a peak of 295 ppbv), NO2 (<2 ppbv–47 ppbv) and O3 (4 ppbv–95 ppbv) mixing ratios, all of which showed strong diurnal variation. The values showed large deviations from unity over the measurement period, with mostly negative deviations (< 1), showing that the air masses were dominated by local sources of NOx and that the PSS was not achieved. Positive deviations (> 1) were also observed occasionally, and these data were used to estimate the total peroxy radical (PO2) mixing ratios. This is the first estimate of PO2 reported for the city of Delhi and compares well with the results in the literature.

Chate, D. M., S. D. Ghude, G. Beig, A. S. Mahajan, C. Jena, R. Srinivas, A. Dahiya, & N. Kumar (2014) Deviations from the O3–NO–NO2 photo-stationary state in Delhi, ATMOSPHERIC ENVIRONMENT 96:353-358.

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PARTICULATE MATTER AIR POLLUTION

Long-term source apportionment of ambient fine particulate matter (PM2.5) in the Los Angeles Basin: A focus on emissions reduction from vehicular sources

Abstract - Positive Matrix Factorization (PMF) was utilized to quantify sources of ambient PM2.5 in central Los Angeles (LA) and Rubidoux, using the Speciation Trends Network data, collected between 2002 and 2013. Vehicular emissions (including gasoline and diesel vehicles) were the second major contributor to PM2.5, following secondary aerosols, with about 20% contribution to total mass in both sites. Starting in 2007, several major federal, state, and local regulations on vehicular emissions were implemented. To assess the effect of these regulations, daily-resolved vehicular source contributions from 2002 to 2006 were pooled together and compared to the combination of 2008 to 2012 datasets. Compared to the 2002–2006 dataset, the median values of vehicular emissions in 2008–2012 statistically significantly decreased by 24 and 21% in LA and Rubidoux, respectively. These reductions were noted despite an overall increase or similarity in the median values of the daily flow of vehicles after 2007, at the sites.

Hasheminassab, S., N. Daher, B. D. Ostro, & C. Sioutas (2014) Long-term source apportionment of ambient fine particulate matter (PM2.5) in the Los Angeles Basin: A focus on emissions reduction from vehicular sources, ENVIRONMENTAL POLLUTION 193:54-64.

Enhanced sulfate formation during China's severe winter haze episode in January 2013 missing from current models

Abstract – A regional haze with daily PM2.5 (fine particulate matters with diameters less than 2.5 m) exceeding 500 g/m3 lasted for several days in January 2013 over North China, offering an

opportunity to evaluate models. Observations show that inorganic aerosols (sulfate, nitrate, and ammonium) are the largest contributor to PM2.5 during the haze period, while sulfate shows the largest enhancement ratio of 5.4 from the clean to haze period. The nested-grid GEOS-Chem model reproduces the distribution of PM2.5 and simulates up to 364 g/m3 of daily maximum PM2.5. Yet on average, the model is a factor of 3 and 4 lower in PM2.5 and fails to capture the large sulfate enhancement from the clean to haze period. A doubling of SO2 emissions over North China, along with daily meteorology corrections, would be required to reconcile model results with surface SO2 observations, but it is not sufficient to explain the model discrepancy in sulfate. Heterogeneous uptake of SO2 on deliquesced aerosols is proposed as an additional source of sulfate under high-relative humidity conditions during the haze period. Parameterizing this process in the model improves the simulated spatial distribution and results in a 70% increase of sulfate enhancement ratio and a 120% increase in sulfate fraction in PM2.5. Combined adjustments in emissions, meteorology, and sulfate chemistry lead to higher sulfate by a factor of 3 and 50% higher PM2.5, significantly reducing the model's low bias during the haze.

Wang, Y., Q. Zhang, J. Jiang, W. Zhou, B. Wang, K. He, F. Duan, Q. Zhang, S. Philip, & Y. Xie (2014) Enhanced sulfate formation during China's severe winter haze episode in January 2013 missing from current models, Journal of Geophysical Research: Atmospheres 119(17):10,425-10,440.

Evaluating clouds, aerosols, and their interactions in three global climate models using satellite simulators and observations

Abstract - Accurately representing aerosol-cloud interactions in global climate models is challenging. As parameterizations evolve, it is important to evaluate their performance with appropriate use of observations. In this investigation we compare aerosols, clouds, and their interactions in three global climate models (Geophysical Fluid Dynamics Laboratory-Atmosphere Model 3 (AM3), National Center for Atmospheric Research-Community Atmosphere Model 5 (CAM5), and Goddard Institute for Space Studies-ModelE2) to Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) satellite observations. Modeled cloud properties are diagnosed using a MODIS simulator. Cloud droplet number concentrations (N) are computed identically from satellite-simulated and MODIS-observed values of liquid cloud optical depth and droplet effective radius. We find that aerosol optical depth (a) simulated by models is similar to observations in many regions around the globe. For N, AM3 and CAM5 capture the observed spatial pattern of higher values in coastal marine stratocumulus versus remote ocean regions, though modeled values, in general, are higher than observed. Aerosol-cloud interactions were computed as the sensitivity of ln(N) to ln(a) for coastal marine liquid clouds near South Africa (SAF) and Southeast Asia where a varies in time. AM3 and CAM5 are more sensitive than observations, while the sensitivity for ModelE2 is statistically insignificant. This widely used sensitivity could be subject to misinterpretation due to the confounding influence of meteorology on both aerosols and clouds. A simple framework for assessing the sensitivity of ln(N) to ln(a) at constant meteorology illustrates that observed sensitivity can change from positive to statistically insignificant when including the confounding influence of relative humidity. Satellite-simulated versus standard model values of N are compared; for CAM5 in SAF, standard model values are significantly lower than satellite-simulated values with a bias of 83 cm 3.

Ban-Weiss, G. A., L. Jin, S. E. Bauer, R. Bennartz, X. Liu, K. Zhang, Y. Ming, H. Guo, & J. H. Jiang (2014) Evaluating clouds, aerosols, and their interactions in three global climate models using satellite simulators and observations, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(18):10,876-10,901.

Change in surface energy balance in Alaska due to fire and spring warming, based on upscaling eddy covariance measurements

Abstract - Warming in northern high latitudes has changed the energy balance between terrestrial ecosystems and the atmosphere. This study evaluated changes in regional surface energy exchange in Alaska from 2000 to 2011 when substantial declines in spring snow cover due to spring warming and large-scale fire events were observed. Energy fluxes from a network of 20 eddy covariance sites were upscaled using a support vector regression (SVR) model, by combining satellite remote sensing data and global climate data. Based on site-scale analysis, SVR reproduced observed net radiation, sensible

heat flux, latent heat flux, and ground heat flux; 8 day root-mean-square errors for these variables were 15, 10, 9, and 3 W m 2, respectively. Based on upscaled fluxes, decreases in spring snow cover induced an increase in surface net radiation, a net heating effect, of 0.56 W m 2 decade 1. This heating effect was comparable to the net cooling effect due to increased fire extent during the study period (up to 0.59 W m 2 decade 1). These land cover effects were larger than the change in the energy forcing associated with CO2 balance for the Alaska region. Spring warming and postfire land cover change increased the regional latent heat flux. The regional sensible heat flux decreased with the postfire land cover change. Our results highlight the importance of positive spring snow albedo feedback to climate and a postfire negative feedback under the expected warming climate in the Arctic.

Ueyama, M., K. Ichii, H. Iwata, E. S. Euskirchen, D. Zona, A. V. Rocha, Y. Harazon, C. Iwama, T. Nakai, & W. C. Oechel (2014) Change in surface energy balance in Alaska due to fire and spring warming, based on upscaling eddy covariance measurements, JOURNAL OF GEOPHYSICAL RESEARCH: BIOGEOSCIENCES 199(10):1,947-1969.

Radiation Budget Biases in AMIP5 Models over the East Asian Monsoon Region

Abstract - The abilities of 27 Atmospheric Model Intercomparison Projection models to simulate the radiation budget (RB) over the East Asian Monsoon region (EAMR) are analyzed based on Clouds and the Earth's Radiant Energy System Energy Balanced and Filled, hereafter CERES, products. The regional mean values of annual top of the atmosphere (TOA) net RB in the simulations are constantly larger than the CERES values in the majority of the models (24 of 27), due mainly to the overestimation of its shortwave (SW) component. The TOA SW RB overestimation in most models (25 of 27) is due mainly to the insufficient SW absorption by the atmosphere and the consequent superfluous downwelling shortwave radiation reaching and being absorbed by the surface. Both the intensity underestimation of SW cloud radiative forcing (CRF) and the inadequate clear-sky atmospheric SW absorption contribute to the overestimation of TOA SW RB in the models. The underestimation of SW CRF intensity is mainly due to the reduced total cloud cover simulated in most of the models compared with the general circulation model -oriented CALIPSO Cloud Product. Black carbon explains the greatest part of the clear-sky atmospheric SW absorption biases in most of the models. The persistent underestimation of TOA SW CRF intensity over the EAMR across all seasons largely explains the seasonally constant overestimation of TOA SW RB. The seasonal variation in clear-sky LW RB demonstrates the remarkable seasonal variation in atmospheric and surface LW RB biases.

Wang, F., S. Yang, & T. Wu (2014) Radiation Budget Biases in AMIP5 Models over the East Asian Monsoon Region, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Accepted Article).

Urbanization and the carbon cycle: Current capabilities and research outlook from the natural sciences perspective

Abstract - This paper explores the urban carbon cycle from the natural sciences perspective, identifying key knowledge gaps and priority areas for future research. The combination of large, concentrated carbon fluxes and rapid change makes cities key elements of the carbon cycle and offers the potential for them to serve as "first responders" for climate action. Estimates of urban-scale carbon fluxes are significantly more uncertain than at larger spatial scales, in part because past studies have mostly avoided local/urban scales where the mix of anthropogenic and natural fluxes is complex and difficult to observationally isolate. To develop effective emission reduction policies, we need to understand emission sources and how they may be changing. Such improved quantification and understanding of underlying processes at the urban scale will not only provide policy-relevant information and improve the understanding of urban dynamics and future scenarios, but will also translate into better global-scale anthropogenic flux estimates, and advance our understanding of carbon cycle and climate feedbacks across multiple scales. Understanding the relationship between urbanization and urban carbon flows requires intellectual integration with research communities beyond the natural sciences. Cities can serve as interdisciplinary process laboratories that are sufficiently constrained in both spatial and governance scale to support truly integrated research by

the natural sciences, social sciences, and engineering. A thoughtfully crafted science research agenda that is grounded in sustained, dense observations relevant to estimating urban carbon fluxes and their controlling processes and is focused on a statistically significant sample of cities will advance our understanding of the carbon cycle.

Hutyra, L. R., R. Duren, K. R. Gurney, N. Grimm, E. A. Kort, E. Larson, & G. Shrestha (2014) Urbanization and the carbon cycle: Current capabilities and research outlook from the natural sciences perspective, EARTH'S FUTURE 2(10):473-495.

Robust response of Asian summer monsoon to anthropogenic aerosols in CMIP5 models

Abstract - The representation of aerosol processes and the skill in simulating the Asian summer monsoon vary widely across climate models. Yet, for the second half of the twentieth century, the models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) show a robust decrease of average precipitation in the South and Southeast Asian (SSEA) continental region due to the increase of anthropogenic aerosols. When taking into account anthropogenic aerosols as well as greenhouse gases (GHGs), the 15 CMIP5 models considered in this study yield an average June–September precipitation least squares linear trend of 0.20 0.20 mmd 1 (50 years) 1, or 2.9%, for all land points in the SSEA region (taken from 75 to 120 E and 5 to 30 N) in the years from 1950 to 1999 (multimodel average one standard deviation) in spite of an increase in the water vapor path of +0.99 0.65 kgm 2 (50 years) 1 (+2.5%). This negative precipitation trend differs markedly from the positive precipitation trend of +0.29 0.14 mmd 1 (50 years) 1, or +4.1%, which is computed for GHG forcing only. Taking into account aerosols both decreases the water vapor path and slows down the monsoon circulation as suggested by several previous studies. At smaller scales, however, internal variability makes attributing observed precipitation changes to anthropogenic aerosols more difficult. Over Northern Central India (NCI), the spread between precipitation trends from individual model realizations is generally comparable in magnitude to simulated changes due to aerosols, and the model results suggest that the observed drying in NCI might in part be explained by internal variability.

Salzmann, M., H. Weser, & R. Cherian (2014) Robust response of Asian summer monsoon to anthropogenic aerosols in CMIP5 models, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(19):11,321-11,337.

Submicron NE Atlantic marine aerosol chemical composition and abundance: Seasonal trends and air mass categorization

Abstract - Three years of continuous Aerosol Mass Spectrometry measurements at the Mace Head Global Atmosphere Watch research station revealed seasonal patterns in the chemical composition of submicron NE Atlantic marine aerosol as well as distinct chemical signatures associated with marine air masses of different origin (i.e., polar, Arctic, or tropical). Concentrations of secondary inorganic aerosol species and both primary and secondary organic compounds were closely related to oceanic biological activity and ranged from low median mass concentrations during winter to high median values during summer as follows: 0.025–0.9 g m 3 for nonsea-salt sulfate (nss-sulfate), 0.025–0.4 g m 3 for organic matter, 0–0.09 g m 3 for methanesulfonic acid (MSA). Sea-salt concentrations illustrated an opposite pattern with the highest median value being observed during winter (0.74 g m 3) and lowest during summer (0.08 g m 3). Maritime polar air masses typically featured the highest concentrations of sea salt and marine organics, particularly enhanced under primary organic plumes during periods of high biological activity. MSA and nss-sulfate were more prominent in tropical air masses. The oxidation of organic matter increased with increasing ozone concentration and wintertime (low biological activity) organic matter displayed a different fragmentation pattern from that of summertime organic compounds.

Ovadnevaite, J., D. Ceburnis, S. Leinert, M. Dall'Osto, M. Canagaratna, S. O'Doherty, H. Berresheim, & C. O'Dowd (2014) Submicron NE Atlantic marine aerosol chemical composition and abundance: Seasonal trends and air mass categorization, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(20):11,850-11,863.

Aerosol emissions from prescribed fires in the United States: A synthesis of laboratory and aircraft measurements

Abstract - Aerosol emissions from prescribed fires can affect air quality on regional scales. Accurate representation of these emissions in models requires information regarding the amount and composition of the emitted species. We measured a suite of submicron particulate matter species in young plumes emitted from prescribed fires (chaparral and montane ecosystems in California; coastal plain ecosystem in South Carolina) and from open burning of over 15 individual plant species in the laboratory. We report emission ratios and emission factors for refractory black carbon (rBC) and submicron nonrefractory aerosol and compare field and laboratory measurements to assess the representativeness of our laboratory-measured emissions. Laboratory measurements of organic aerosol (OA) emission factors for some fires were an order of magnitude higher than those derived from any of our aircraft observations; these are likely due to higher-fuel moisture contents, lower modified combustion efficiencies, and less dilution compared to field studies. Nonrefractory inorganic aerosol emissions depended more strongly on fuel type and fuel composition than on combustion conditions. Laboratory and field measurements for rBC were in good agreement when differences in modified combustion efficiency were considered; however, rBC emission factors measured both from aircraft and in the laboratory during the present study using the Single Particle Soot Photometer were generally higher than values previously reported in the literature, which have been based largely on filter measurements. Although natural variability may account for some of these differences, an increase in the BC emission factors incorporated within emission inventories may be required, pending additional field measurements for a wider variety of fires.

May, A. A., G. R. McMeeking, T. Lee, J. W. Taylor, J. S. Craven, I. Burling, A. P. Sullivan, S. Akagi, J. L. Collett Jr., M. Flynn, H. Coe, S. P. Urbanski, J. H. Seinfeld, R. J. Yokelson, & S. M. Kreidenweis (2014) Aerosol emissions from prescribed fires in the United States: A synthesis of laboratory and aircraft measurements, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(20):11,826-11,849.

A possible link between wildfire aerosol and North American Monsoon precipitation in Arizona–New Mexico

Abstract - Previous research highlights the dominant role of Pacific sea surface temperatures (SSTs) and their associated large-scale teleconnections in modulating the North American monsoon (NAM). At the regional scale, feedbacks associated with land-surface boundary conditions have been shown to provide 'memory' in the system. Here, a previously unexplored second-order linkage between aerosol generated by late-spring wildfires and subsequent summer precipitation delivered by the NAM in the Arizona-New Mexico (AZNM) region is proposed. Correlations between June/July organic carbon and elemental carbon (OC/EC) in Inter-agency Monitoring of Protected Visual Environments (IMPROVE) aerosol data (Gila Wilderness and Bandelier) and NAM precipitation in southern AZNM over the period 1994–2012 are shown to be negative ($r = -0.4$), suggesting that active antecedent wildfire seasons tend to be immediately followed by a weak late summer monsoon. This result is consistent with a previous study linking precipitation and area burned in wildfires in AZNM. A survey of extant literature suggests a sound basis for potential mechanisms related to convective processes and cloud microphysics, and furthermore suggests that this forcing could be of similar magnitude to well-documented land-based second-order NAM forcings (antecedent snowpack and soil moisture, vegetation, and mineral dust). Based on these results, we believe that the role of aerosols in modulating summer precipitation deserves further investigation both observationally and in modeling studies. If indeed wildfire smoke does contribute to the modulation of NAM intensity, by virtue of its close temporal association with NAM season, it may well represent a factor that could contribute effectively to improved seasonal prediction of summer precipitation in the NAM region.

McKendry, I. G., & D. S. Gutzler (2014) A possible link between wildfire aerosol and North American Monsoon precipitation in Arizona–New Mexico, INTERNATIONAL JOURNAL OF CLIMATOLOGY (early view).

Changing temperature and precipitation extremes in the Hindu Kush-Himalayan region: an analysis of CMIP3 and CMIP5 simulations and projections

Abstract - The Hindu Kush-Himalayan (HKH) region epitomizes a geographic region where cryospheric processes coupled with hydrological regimes are under threat owing to a warming climate and shifts in climate extremes. In this study, we analyse global climate models in the Coupled Model Intercomparison Project phase 3 (CMIP3) and phase 5 (CMIP5) archives to investigate the qualitative aspects of change and trends in temperature and precipitation indices. Specifically, we examine and evaluate multi-model, multi-scenario climate change projections and seven extreme temperature and precipitation indices over the eastern Himalaya (EH) and western Himalaya-Karakoram (WH) regions for the 21st century. Density distribution plots of observed climate indices for meteorological stations and gridded indices are also analysed, which indicate significant negative trends in the annual number of frost days and significant increasing trends in warm nights in the EH region over the 1960–2000 period. Multi-model average (MMA) projections additionally indicate continued trends towards more extreme conditions consistent with a warmer, wetter climate. Precipitation projections indicate increased mean precipitation with more frequent extreme rainfall during monsoon season in the EH region, and a wetter cold season in the WH region. Time series of all MMA precipitation indices exhibit significant increasing trends over the 1901–2099 period. By comparison, time series of temperature indices show decreases in the intra-annual extreme temperature range and total number of frost days, as well as increases in warm nights. In general, these future projections point towards increases in summertime temperatures and modifications in precipitation across both regions.

Panday, P. K., J. Thibeault, & K. E. Frey (2014) Changing temperature and precipitation extremes in the Hindu Kush-Himalayan region: an analysis of CMIP3 and CMIP5 simulations and projections, INTERNATIONAL JOURNAL OF CLIMATOLOGY (Early View).

Global observations of aerosol-cloud-precipitation-climate interactions

Abstract - Cloud drop condensation nuclei (CCN) and ice nuclei (IN) particles determine to a large extent cloud microstructure and, consequently, cloud albedo and the dynamic response of clouds to aerosol-induced changes to precipitation. This can modify the reflected solar radiation and the thermal radiation emitted to space. Measurements of tropospheric CCN and IN over large areas have not been possible and can be only roughly approximated from satellite-sensor-based estimates of optical properties of aerosols. Our lack of ability to measure both CCN and cloud updrafts precludes disentangling the effects of meteorology from those of aerosols and represents the largest component in our uncertainty in anthropogenic climate forcing. Ways to improve the retrieval accuracy include multiangle and multipolarimetric passive measurements of the optical signal and multispectral lidar polarimetric measurements. Indirect methods include proxies of trace gases, as retrieved by hyperspectral sensors. Perhaps the most promising emerging direction is retrieving the CCN properties by simultaneously retrieving convective cloud drop number concentrations and updraft speeds, which amounts to using clouds as natural CCN chambers. These satellite observations have to be constrained by in situ observations of aerosol-cloud-precipitation-climate (ACPC) interactions, which in turn constrain a hierarchy of model simulations of ACPC. Since the essence of a general circulation model is an accurate quantification of the energy and mass fluxes in all forms between the surface, atmosphere and outer space, a route to progress is proposed here in the form of a series of box flux closure experiments in the various climate regimes. A roadmap is provided for quantifying the ACPC interactions and thereby reducing the uncertainty in anthropogenic climate forcing.

Rosenfeld, D., M. O. Andreae, A. Asmi, M. Chin, G. de Leeuw, D. P. Donovan, R. Kahn, S. Kinne, N. Kivekäs, M. Kulmala, W. Lau, K. S. Schmidt, T. Suni, T. Wagner, M. Wild, & J. Quaas (2014) Global observations of aerosol-cloud-precipitation-climate interactions, Reviews of Geophysics (Early View).

Global simulations of aerosol amount and size using MODIS observations assimilated with an Ensemble Kalman Filter

Abstract - A global assimilation that uses an Ensemble Kalman Filter and a set of derived scaling equations is presented for jointly adjusting the amount of atmospheric aerosol and the relative contribution of fine and coarse aerosols. The assimilation uses Department of Energy and National

Science Foundation's Community Atmosphere Model (CAM) model and aerosol optical depth (AOD) and Angstrom exponent (AE) retrievals from NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) instrument. Aerosol Robotic Network (AERONET) AE retrievals are used to constrain size over land. The presented system includes 60 ensemble members with a daily analysis, incorporating daily-averaged retrievals. A CAM control simulation and a CAM experiment with data assimilation (CAM-DA) are run for the year 2007. Control run comparisons to MODIS observations reveal a persistent negative bias in AOD, indicating an underprediction of the amount of atmospheric aerosol (CAM: 0.09 (0.06), MODIS:0.16 (0.09)). The negative bias decreased in the assimilation run with a globally averaged AOD of 0.12 (0.05). CAM-DA is able to better capture spatial and temporal variations. A comparison of regional time series reveals the greatest reduction in model bias with respect to both aerosol amount and size over the oceans, especially the Southern Ocean. With respect to land regions, good agreement with AERONET AOD is found over the United States, Europe, and East Asia. Additionally, CAM-DA has clear spatial differences from the control with more aerosol and a larger fine contribution in the Northern Hemisphere. The results also demonstrate the utility in assimilation methodologies for identifying systematic model biases, using the data assimilation correction fields as an indicator.

Rubin, J. I., & W. D. Collins (2014) Global simulations of aerosol amount and size using MODIS observations assimilated with an Ensemble Kalman Filter, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Early View).

Properties of light-absorbing aerosols in the Nagoya urban area, Japan, in August 2011 and January 2012: Contributions of brown carbon and lensing effect

Abstract - The optical properties of aerosols at 405 and 781 nm were measured in an urban site in Nagoya, Japan, in August 2011 and in January 2012 using a photoacoustic spectrometer. Comparison of the absorption coefficient at 781 nm of aerosols that did and did not pass through a thermo-denuder showed that an increase in black carbon (BC) light absorption due to the coating of non-refractory materials (i.e., the lensing effect) was small (on average, 10%) in August and negligible in January. The effective density distributions for the particles that did and did not pass through the thermo-denuder, which were measured simultaneously in August, suggested that the majority of BC particles sampled had a minimal coating. The small lensing effect observed can be explained partly by assuming that a large portion of non-refractory materials was mixed externally with BC. The contribution of direct light absorption by organic matter (OM) that vaporized at temperatures below 300 C to the total light absorption at 405 nm was negligible in August, but those by OM that vaporized below 300 and 400 C averaged 11 and 17%, respectively, in January. The larger contribution of light-absorbing OM in January is likely due to the greater contribution of OM originating from the burning of biomass, including biofuel and agricultural residue, in Japan, northern China, or Siberia, during the winter.

Nakayama, T., Y. Ikeda, Y. Sawada, Y. S. S. Ogawa, K. Kawana, M. Mochida, F. Ikemori, K. Matsumoto, & Y. Matsumi (2014) Properties of light-absorbing aerosols in the Nagoya urban area, Japan, in August 2011 and January 2012: Contributions of brown carbon and lensing effect, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Early View).

The Many Faces of Soot: Characterization of Soot Nanoparticles Produced by Engines

Abstract - Soot nanoparticles produced by engines constitute a threat to human health. For the analytical chemist, soot is a hard nut to crack as the released particles undergo rapid changes in their size, shape, and number concentration. The complete characterization of soot will be essential to meet future low-emission standards. Besides measuring the light extinction, modern analytical chemistry can determine a variety of less-known effects, such as condensation properties, immune response in vertebrates, and impact on the cardiovascular function of a beating heart. Photon emission and in particular Raman spectroscopy provides information on the nanocrystallinity, while thermoelectron emission allows the number of electrical particles to be counted. Even the "simple" combustion of soot nanoparticles offers potential for the characterization of the particles.

Niessner, R. (2014) The Many Faces of Soot: Characterization of Soot Nanoparticles Produced by Engines, Angewandte Chemie International Edition 53(46):12,366-12,379.

Climatology of long-range transported Asian dust along the West Coast of the United States

Abstract - The contribution of trans-Pacific dust estimated from satellite observations has been shown to be 3 times greater than domestic dust in North America throughout the year. Thus, a quantitative understanding of the frequency and locations where Asian dust is transported is necessary to improve global dust modeling for weather and climate predictions. This work presents a 10 year record (2002–2011) of dust along the U.S. West Coast estimated from the Interagency Monitoring of Protected Visual Environments network in an effort to characterize the seasonal cycle and interannual variability of Asian dust transport. In addition, observations of dust exported from East Asia were analyzed along with air mass trajectories and satellite and ground-based precipitation data to investigate seasonal variability of Asian dust transport. On average, Asian dust concentrations (0.08–0.60 g m 3) from ground-based observations were 1.7 times those of local dust (0.00–0.53 g m 3) and 23% (up to 44%) of fine particulate matter (particles with diameters 2.5 micrometers, or PM2.5) mass concentrations at high elevations in the spring. The maximum in springtime Asian dust on the U.S. West Coast was attributed to higher source concentrations (10.98–36.27 g m 3) and reduced potential for wet removal over the Pacific Ocean and U.S. West Coast. Although trans-Pacific transport was more favorable during the winter, minimum concentrations of Asian dust were observed on the U.S. West Coast (0.11 g m 3) due to a lower source influence and higher potential for wet removal during transport. Multiobservational approaches such as these should be taken into account when modeling transport of Asian dust to the western U.S.

Creamean, J. M., J. R. Spackman, S. M. Davis, & A. B. White (2014) Climatology of long-range transported Asian dust along the West Coast of the United States, Journal of Geophysical Research: Atmospheres 119(21):12,171-12,185.

Impacts of nonrefractory material on light absorption by aerosols emitted from biomass burning

Abstract - We present laboratory measurements of biomass-burning aerosol light-scattering and light absorption coefficients at 405, 532, and 781 nm and investigate their relationship with aerosol composition and fuel type. Aerosol composition measurements included nonrefractory components measured by a high-resolution aerosol mass spectrometer (AMS), composition of refractory black carbon-containing particles by a soot particle aerosol mass spectrometer (SP-AMS), and refractory black carbon measured by a single-particle soot photometer (SP2). All measurements were performed downstream of a thermal denuder system to probe the effects of nonrefractory material on observed optical properties. The fires studied emitted aerosol with a wide range of optical properties with some producing more strongly light-absorbing particles (single-scattering albedo or SSA at 781 nm = 0.4) with a weak wavelength dependence of absorption (absorption Ångström exponent or AAE = 1–2) and others producing weakly light-absorbing particles (SSA at 781 nm ~1) with strong wavelength dependence of absorption (AAE ~7). Removal of nonrefractory material from the particles by the thermal denuder system led to substantial (20–80%) decreases in light absorption coefficients, particularly at shorter wavelengths, reflecting the removal of light-absorbing material that had enhanced black carbon absorption in internally mixed untreated samples. Observed enhancements of absorption by all mechanisms were at least factors of 1.2–1.5 at 532 nm and 781 nm as determined from the heated samples. A mass absorption cross-section-based approach indicated larger enhancements, particularly at shorter wavelengths.

McMeeking, G. R., E. Fortner, T. B. Onasch, J. W. Taylor, M. Flynn, H. Coe, & S. M. Kreidenweis (2014) Impacts of nonrefractory material on light absorption by aerosols emitted from biomass burning, Journal of Geophysical Research: Atmospheres 119(21):12,272-12,286.

Spatial and seasonal patterns in urban influence on regional concentrations of speciated aerosols across the United States

Abstract - Monthly, seasonal, and annual mean estimates of urban influence on regional concentrations of major aerosol species were computed using speciated aerosol data from the rural IMPROVE network (Interagency Monitoring of Protected Visual Environments) and the United States Environmental Protection Agency's urban Chemical Speciation Network for the 2008 through 2011 period. Aggregated for sites across the continental United States, the annual mean and one standard error in urban excess (defined as the ratio of urban to nearby rural concentrations) was highest for elemental carbon (3.3 0.2), followed by ammonium nitrate (2.5 0.2), particulate organic matter (1.78 0.08), and ammonium sulfate (1.23 0.03). The seasonal variability in urban excess was significant for carbonaceous aerosols and ammonium nitrate in the West, in contrast to the low seasonal variability in the urban influence of ammonium sulfate. Generally for all species, higher excess values in the West were associated with localized urban sources while in the East excess was more regional in extent. In addition, higher excess values in the western United States in winter were likely influenced not only by differences in sources but also by combined meteorological and topographic effects. This work has implications for understanding the spatial heterogeneity of major aerosol species near the interface of urban and rural regions and therefore for designing appropriate air quality management strategies. In addition, the spatial patterns in speciated mass concentrations provide constraints for regional and global models.

Hand1, J. L., B. A. Schichtel, W. C. Malm, M. Pitchford, & N. H. Frank (2014) Spatial and seasonal patterns in urban influence on regional concentrations of speciated aerosols across the United States, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES (Early View).

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 cancellation 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 0.028 W m 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 (2014) Uncertainty in the magnitude of aerosol-cloud radiative forcing over recent decades, GEOPHYSICAL RESEARCH LETTERS (Accepted Articles).

Impact of long-range transport of aerosols on the PM2.5 composition at a major metropolitan area in the northern Kyushu area of Japan

Abstract - In view of the recent rapid economic growth and accompanying energy consumption in the East Asian region, particularly in China, there is much concern about the effects of emitted particulate pollutants on human health. We have thus investigated the impact of long-range transport of aerosols on urban air quality in the upwind areas of Japan by comparing the PM2.5 composition collected for multiple years in Fukuoka, a representative metropolis in the Kyushu area, and in Fukue Island, located 190 km southwest of Fukuoka. Daily averaged PM2.5 concentrations in Fukuoka and Fukue were almost identical. PM2.5 concentrations at these sites were dominated by sulfate and particulate organics, and their fluctuation patterns were similar except for organics in the warm season. In contrast, those of nitrate and elemental carbon differed substantially between the sites. In addition, the ratios of Pb/Zn and Cd/Pb in Fukuoka were close to the reported values in Beijing. Non-sea-salt sulfate concentration in Fukuoka measured in this study and reported in the past measurements

apparently coincided with the decadal SO2 emission change in China reported in a recent emission inventory. Therefore, we conclude that even in a city as large as Fukuoka, the PM2.5 concentration in the northern part of the Kyushu area is primarily dominated by the inflow of long-range transported aerosols throughout the year, except in the summer, rather than local air pollution emitted at each site.

Kaneyasu, N., S. Yamamoto, K. Sato, A. Takami, M. Hayashi, K. Hara, K. Kawamoto, T. Okuda, & S. Hatakeyama (2014) Impact of long-range transport of aerosols on the PM2.5 composition at a major metropolitan area in the northern Kyushu area of Japan, ATMOSPHERIC ENVIRONMENT 97:416-425.

New atmospheric composition observations in the Karakorum region: Influence of local emissions and large-scale circulation during a summer field campaign

Abstract - In this work we provide an overview of short lived climate forcers (SLCFs) and carbon dioxide variability in the Karakorum, by presenting results deriving from a field campaign carried out at Askole (3015 m a.s.l., Pakistan Northern Areas), by Baltoro glacier. By using an innovative embedded and transportable system, continuous measurements of aerosol particle number concentration (Np, 1571 2670 cm 3), surface ozone (O3, 31.7 10.4 nmol/mol), carbon dioxide (CO2, 394.3 6.9 μmol/mol) and meteorological parameters have been performed from August 20th to November 10th 2012. The domestic combustion from the Askole village emerged as a possible systematic source of contamination in the valley, with short-lasting pollution events probably related to domestic cooking activities characterized by high values of Np (6066 5903 cm 3). By excluding these local contamination events, mountain thermal wind regime dominated the diurnal variability of Np, O3 and CO2. In comparison to night-time, we observed higher Np (+354 cm 3) and O3 (+7 nmol/mol) but lower CO2 (8 μmol/mol) in air-masses coming from the lower valley during the central part of the day. Part of the day-to-day atmospheric composition variability can be also ascribed to synoptic circulation variability, as observed by using HYSPLIT 5-day back-trajectories.

Putero, D., P. Cristofanelli, P. Laj, A. Marinoni, P. Villani, A. Broquet, M. Alborghetti, U. Bonafè, F. Calzolari, R. Duchi, T.C. Landi, G.P. Verza, E. Vuillermoz, & P. Bonasoni (2014) New atmospheric composition observations in the Karakorum region: Influence of local emissions and large-scale circulation during a summer field campaign, ATMOSPHERIC ENVIRONMENT 97:75-82.

Measuring ambient particulate matter in three cities in Cameroon, Africa

Abstract - This is the first study of particulate matter (PM) air pollution in Cameroon. In this study, mass concentration and PM size fractions as well as carbonaceous contribution to PM are measured in Bafoussam, Bamenda, and Yaoundé, Cameroon. Average concentrations in Bafoussam, Bamenda, and Yaoundé of PM2.5 are 67 14, 132 64, and 49 12 μg/m3 and PM10 are 105 29, 141 107, and 65 21 μg/m3, respectively. Daytime levels of PM2.5 and PM10 are seen to be higher than nighttime levels in all cities except Bamenda where nighttime levels are higher for both PM sizes. In Bafoussam, the average PM1.0 particle number concentration during the day is 19,800 pt/cc and during the evening is 15,200 pt/cc. PM2.5/PM10 mass ratios are 0.65 0.05, 0.75 0.05, and 0.78 0.09 for Bafoussam, Bamenda, and Yaounde, respectively. Elemental carbon (EC) and organic carbon (OC) contribution to PM2.5 in Bafoussam, Bamenda, and Yaoundé are 3.9%, 2.9% and 12% for EC and 17.7%, 23.6%, and 34.2% for OC, respectively. After conducting spatial variability of PM mass concentration and size fractionation sampling at various locations within each of the three cities, we find that PM2.5 averages are highest during commercial meal preparation in Bafoussam (684 546 μg/m3), and on the road in Bamenda (417 113 μg/m3) and Yaoundé (110 57 μg/m3). Additional air quality research in Central and West Africa is necessary to begin implementing policy steps that influence change and to advocate for improved health conditions in this rapidly expanding region of the world.

Antonel, J. & Z. Chowdhury (2014) Measuring ambient particulate matter in three cities in Cameroon, Africa, ATMOSPHERIC ENVIRONMENT, 95:344-354.

Organic aerosols in the southeastern United States: Speciated particulate carbon measurements from the SEARCH network, 2006–2010

Abstract – This study describes and analyzes measurements of 119 non-polar organic compounds in PM2.5 samples from three urban sites in the Southeastern Aerosol Research and Characterization (SEARCH) network: Jefferson Street in Atlanta, Georgia (JST), Birmingham, Alabama (BHM), and Hinton, Texas (HIN). Daily 24-h PM2.5 samples were collected on quartz-fiber filters from January 2006 through 2007 at HIN and from March 2006 through 2010 at JST and BHM. PM2.5 sampling at BHM and JST is ongoing. The measured species are associated with directly emitted particles and potentially serve as tracers of specific types of emissions. PM2.5 organic measurements include 28 n-alkanes (C15–C42), 18 iso-/anteiso-alkanes (C29–C37), 2 methyl alkanes, 3 branched alkanes, 5 cycloalkanes, 32 PAH compounds, 18 hopanes, 12 steranes, and 1 alkene, many of which are constituents of motor-vehicle exhaust and other anthropogenic PM2.5 emissions. Predominantly anthropogenic origins of the measured compounds are indicated by weekly and seasonal cycles that are identified with known emission patterns, especially for motor vehicle usage. Annual mean concentrations of each class of compounds declined by 60–90% from 2006 through 2009, then increased in 2010 to concentrations comparable to 2008. These changes are similar to 40% reductions of on-road and non-road motor-vehicle exhaust PM2.5 emissions between 2006 and 2010. Year-to-year variations in OC correlated with year-to-year variations in measured non-polar compound concentrations. Regression of OC against the sums of measured n-alkanes, iso-/anteiso-alkanes, PAHs, hopanes, and steranes indicates that 32 7% of OC at BHM and 35 4% of OC at JST derived from sources emitting the measured non-polar compounds. The reductions in measured concentrations of EC, OC, and non-polar OC species represent an important improvement in air quality in the southeastern U.S. that can be attributed by the long-term measurement program to PM2.5 emission reductions.

Blanchard, C. L., J. C. Chow, E. S. Edgerton, J. G. Watson, G. M. Hidy, & S. Shaw (2014) Organic aerosols in the southeastern United States: Speciated particulate carbon measurements from the SEARCH network, 2006–2010, ATMOSPHERIC ENVIRONMENT 95:327-333.

Observations of new particle formation at two distinct Indian subcontinental urban locations

Abstract - While the formation of new atmospheric aerosol particles and their subsequent growth have been observed under diverse environmental conditions globally, such observations are very scarce over Indian subcontinent. Here, we present the systematic analysis for new particle formation (NPF) from two distinct urban locations in India during April–May of two consecutive years. Particle size distributions were measured at Pune (18.53 N, 73.85 E) during 16 April–23 May, 2012 and at Kanpur (26.46 N, 80.32 E) during 16 April–23 May, 2013. The campaign mean total particle number concentration in the similar size range of 4–135 nm at Pune (12.2 103 cm 3) was higher than at Kanpur (7.9 103 cm 3), whereas the estimated total condensation sink (CS4–750) at Pune (16.2 10 3 s 1) was lower than at Kanpur (33.3 10 3 s 1). Despite lower particle number concentrations at Kanpur, larger particle sizes resulted in higher condensation sink than at Pune. The mean particle mode diameter at Kanpur was found larger by a factor of ~1.8 than at Pune. NPF events were observed commonly at both sites, with lower frequency at Kanpur (14%) than that at Pune (26%). The derived particle growth rates, GR, and the formation rates of 5 nm particles, J5, ranged from 3.4 to 13.3 nm h 1 and 0.4 to 13.9 cm 3 s 1, respectively, which are generally comparable to typical values reported in previous studies. Generally, the particle growth rates were found higher at Kanpur, whereas the formation rates were higher at Pune. It appears that the presence of pre-existing large particles at Kanpur than at Pune suppressed formation rates and favored particle growth. Overall, NPF occurred at lower condensation sink, lower RH, higher solar radiation, and higher temperature.

Kanawade, V. P., S. N. Tripathi, D. Siingh, A. S. Gautam, A. K. Srivastava, A. K. Kamra, V. K. Soni, & V. Sethi (2014) Observations of new particle formation at two distinct Indian subcontinental urban locations, ATMOSPHERIC ENVIRONMENT 96:370-379.

Source apportionment of urban fine particle number concentration during summertime in Beijing

Abstract - Continuous particle number size distributions (15 nm–2.5 μm), particle chemical compositions, gaseous species and meteorological variables were collected at an urban site in Beijing to investigate the source apportionment of ambient fine particle number concentrations. Hourly data sets were analyzed using the positive matrix factorisation (PMF) which identified a total of eight factors: two traffic factors, two combustion factors, secondary nitrate factors, secondary sulfate + secondary organic aerosol (SOA), fugitive dust and regionally transported aerosol. Traffic (47.9%) and combustion (29.7%) aerosol were found to dominate the particle number concentrations, whereas the most important sources for particle volume concentrations were found to be regionally transported aerosol (30.9%) and combustions (30.1%). Although the diurnal pattern of each of the two traffic factors closely followed traffic rush hour for Beijing, their size modes were different suggesting that these factors might represent local and remote emissions. Biomass burning and coal-fired power plant aerosol were distinguished according to their size modes and chemical species associated with them. Secondary compounds showed similar bimodal particle number size distribution, the distinct diurnal pattern distinguished these factors as secondary nitrate and mixed source of secondary sulfate and SOA. Regionally transported material was characterized by accumulation mode particles. Overall, the introduction of combinations of particle number size distributions and chemical composition data in PMF model is successful at separating the components and quantifying relative contributions to the particle number and volume size distributions in the complex urban atmosphere.

Liu, Z. R., B. Hu, Q. Liu, Y. Sun, & Y. S. Wang (2014) Source apportionment of urban fine particle number concentration during summertime in Beijing, ATMOSPHERIC ENVIRONMENT 96:359-369.

Indicators reflecting local and transboundary sources of PM2.5 and PMCOARSE in Rome – Impacts in air quality

Abstract - The keystone of this paper was to calculate and interpret indicators reflecting sources and air quality impacts of PM2.5 and PMCOARSE (PM10–PM2.5) in Rome (Italy), focusing on potential exogenous influences. A backward atmospheric trajectory cluster analysis was implemented. The likelihood of daily PM10 exceedances was studied in conjunction with atmospheric patterns, whereas a Potential Source Contribution Function (PSCF) based on air mass residence time was deployed on a grid of a 0.5 0.5 resolution. Higher PM2.5 concentrations were associated with short/medium range airflows originated from Balkan Peninsula, whereas potential PMCOARSE sources were localized across the Mediterranean and coastal North Africa, due to dust and sea spray transportation. According to the outcome of a daily Pollution Index (PI), a slightly increased degradation of air quality is induced due to the additional quantity of exogenous PM but nevertheless, average levels of PI in all trajectory clusters belong in the low pollution category. Gaseous and particulate pollutants were also elaborated by a Principal Component Analysis (PCA), which produced 4 components: [Traffic], [photochemical], [residential] and [Secondary Coarse Aerosol], reflecting local sources of air pollution. PM2.5 levels were strongly associated with traffic, whereas PMCOARSE were produced autonomously by secondary sources.

Dimitriou, K., & P. Kassomenos (2014) Indicators reflecting local and transboundary sources of PM2.5 and PMCOARSE in Rome – Impacts in air quality, ATMOSPHERIC ENVIRONMENT 96:154-162.

Relationship between black carbon and associated optical, physical and radiative properties of aerosols over two contrasting environments

Abstract - The first simultaneous aethalometer and solar radiometer measurements of black carbon (BC) mass concentration (surface-level) and aerosol optical, microphysical and radiative parameters (columnar) have been made during 2005–2011 over two contrasting experimental sites, one representing background rural environment (Sinhagad) and the other surrounded by urban environment (Pune) in the south-west India. The long-term diurnal cycle of BC aerosols over both sites exhibited a strong peak during daytime and a weaker plateau around evening–midnight hours, implying the influence of anthropogenic emissions as well as changes in planetary boundary layer (PBL). The multi-year seasonal mean variation in BC concentration shows the highest during winter

and lowest during monsoon seasons, which is found to be inversely related to the variations in single scattering albedo (SSA). Moreover, the BC variations were found to be strongly associated with greater values of Angstrom exponent ( ), indicating that the observed BC involves abundance of fine-mode aerosol fraction. The higher concentrations of BC during winter and lower concentrations during pre-monsoon over both Pune and Sinhagad are noticed to be closely linked with aerosol optical depth, revealing significant contribution of BC to the composite aerosol over both the regions. The columnar AOD and Angstrom exponent also showed relatively greater optical depth and values during winter as compared to pre-monsoon season over both sites.

Safai, P. D, P. C. S. Devara, M. P. Raju, K. Vijayakumar, & P. S. P. Rao (2014) Relationship between black carbon and associated optical, physical and radiative properties of aerosols over two contrasting environments, ATMOSPHERIC RESEARCH 149:292-299.

Aerosol mass size distribution and black carbon over a high altitude location in Western Trans-Himalayas: Impact of a dust episode

Abstract - The information on the aerosol properties from remote locations provides insights into the background and natural conditions against which anthropogenic impacts could be compared. Measurements of the near surface aerosol mass size distribution from the high altitude remote site help us to understand the natural processes, such as, the association between Aeolian and fluvial processes that have a direct bearing on the mass concentrations, especially in the larger size ranges. In the present study, the total mass concentration and mass-size distribution of the near surface aerosols, measured using a 10-channel Quartz Crystal Microbalance (QCM) Impactor from a high altitude location-Hanle (32.78 N, 78.95 E, 4520 m asl) in the western Trans-Himalayas, have been used to characterize the composite aerosols. Also the impact of a highly localized, short-duration dust storm episode on the mass size distribution has been examined. In general, though the total mass concentration (Mt) remained very low (~0.75 0.61 μg m 3), interestingly, coarse mode (super-micron) aerosols contributed almost 72 6% to the total aerosol mass loading near the surface. The mass-size distribution showed 3 modes, a fine particle mode (~0.2 μm), an accumulation mode at ~0.5 μm, and a coarse mode at ~3 μm. During a localized short duration dust storm episode, Mt reached as high as ~13.5 μg m 3 with coarse mode aerosols contributing to nearly 90% of it. The mass size distribution changed significantly, with a broad coarse mode so that the accumulation mode became inconspicuous. Concurrent measurements of aerosol black carbon (BC) using twin wavelength measurements of the aethalometer showed an increase in the wavelength index of absorption, from the normal values of ~1 to 1.5 signifying the enhanced absorption at the short wavelength (380 nm) by the dust.

Kompalli, S. K., K. K. Moorthy, S. S. Babu, & M. R. Manoj (2014) Aerosol mass size distribution and black carbon over a high altitude location in Western Trans-Himalayas: Impact of a dust episode, AEOLIAN RESEARCH 15:161-168.

Air quality in developing world disaster and conflict zones — The case of post-earthquake Haiti

Abstract - Data on air quality are remarkably limited in the poorest of the world's countries. This is especially true for post-conflict and disaster zones, where international relief efforts focus largely on more salient public health challenges such as water and sanitation, infectious diseases, and housing. Using post-earthquake Haiti as the example case, this commentary explores air quality challenges in the developing world, highlighting concerns related to infrastructure damage from post-conflict and disaster settings. We contend that there is a growing and presently unmet need for further research and attention from the global health community to address these issues.

Davis, M. E., & A. Rappaport (2014) Air quality in developing world disaster and conflict zones — The case of post-earthquake Haiti, SCIENCE OF THE TOTAL ENVIRONMENT 496:22-25.

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Fine particle components and health—a systematic review and meta-analysis of epidemiological time series studies of daily mortality and hospital admissions

Abstract - Short-term exposure to fine particle mass (PM) has been associated with adverse health effects, but little is known about the relative toxicity of particle components. We conducted a systematic review to quantify the associations between particle components and daily mortality and hospital admissions. Medline, Embase and Web of Knowledge were searched for time series studies of sulphate (SO_4^{2-}), nitrate (NO_3^-), elemental and organic carbon (EC and OC), particle number concentrations (PNC) and metals indexed to October 2013. A multi-stage sifting process identified eligible studies and effect estimates for meta-analysis. SO_4^{2-}, NO_3^-, EC and OC were positively associated with increased all-cause, cardiovascular and respiratory mortality, with the strongest associations observed for carbon: 1.30% (95% CI: 0.17%, 2.43%) increase in all-cause mortality per 1 μg/m3. For PNC, the majority of associations were positive with confidence intervals that overlapped 0%. For metals, there were insufficient estimates for meta-analysis. There are important gaps in our knowledge of the health effects associated with short-term exposure to particle components, and the literature also lacks sufficient geographical coverage and analyses of cause-specific outcomes. The available evidence suggests, however, that both EC and secondary inorganic aerosols are associated with adverse health effects.

Atkinson, R. W., I. C Mills, H. A Walton, & H R. Anderson (2014) Fine particle components and health—a systematic review and meta-analysis of epidemiological time series studies of daily mortality and hospital admissions, JOURNAL OF EXPOSURE SCIENCE AND ENVIRONMENTAL EPIDEMIOLOGY (advance online publication).

Personal exposure to ultrafine particles: Two-level statistical modeling of background exposure and time-activity patterns during three seasons

Abstract - Personal exposure to air pollution is associated with time- and location-specific factors including indoor and outdoor air pollution, meteorology and time activities. Our investigation aims at the description and identification of factors determining personal exposure to particle number concentration (PNC) in everyday situations. Ten volunteers recorded their personal exposure to PNC and kept an activity diary in three different seasons besides stationary measurements of ambient air pollution and meteorology. Background exposure to PNC was modelled using the most predictive variables. In a second step, the effects of the activities were calculated adjusted for the background exposure. The average personal PNC level was highest in winter and was three times higher than the mean stationary PNC level while staying indoors and two times higher while staying outdoors. Personal indoor PNC levels were significantly increased during the use of candles, cooking and the occurrence of smell of food. High stationary outdoor PNC levels and low dew point temperatures were associated with increased personal outdoor PNC levels. Times spent in public transport were associated with lower personal PNC levels than other times spent in transportation. Personal PNC levels in everyday situations exhibited a large variability because of seasonal, microenvironment-specific and activity-specific influences.

Deffner, V., H. Küchenhoff, V. Maier, M. Pitz, J. Cyrys, S. Breitner, A. Schneider, J. Gu, U. Geruschkat, & A. Peters (2014) Personal exposure to ultrafine particles: Two-level statistical modeling of background exposure and time-activity patterns during three seasons, J. EXPO. SCI. ENVIRON. EPIDEMIOL.

Global lung cancer risk from PAH exposure highly depends on emission sources and individual susceptibility

Abstract - The health impacts of polycyclic aromatic hydrocarbons (PAHs), the most concerning organic pollutants, depend not only on the locations and strengths of emission sources, but also on individual susceptibility. Moreover, trans-boundary transport makes them a global concern. In this study, a comprehensive analysis of the global health impacts of polycyclic aromatic hydrocarbons (PAHs) in ambient air is presented. Model resolution is critical in exposure modelling. Globally,

incremental lifetime lung cancer risk (ILCR) induced by ambient PAH exposure is 3.1 10 5. If the individual susceptibility was not taken into consideration, the overall risk would be underestimated by 55% and the proportion of highly vulnerable population would be underestimated by more than 90%. Emphasizing on individual susceptibility, our study provides an instrumental revision of current risk assessment methodology. In terms of lung cancer risk, the most important sources are combustion of biomass fuels (40%) and fossil fuels (14%) in the residential/commercial sector, coke (13%) and aluminium (12%) production, and motor vehicles (9%). PAHs can travel long distance globally especially within the Eurasian continent. Still, the risk is dominantly contributed by local.

Shen, H., S. Tao, J. Liu, Y. Huang, H. Chen, W. Li, Y. Zhang, Y. Chen, S. Su, N. Lin, Y. Xu, B. Li, X. Wang & W. Liu (2014) Global lung cancer risk from PAH exposure highly depends on emission sources and individual susceptibility, SCIENTIFIC REPORTS 4(6561).

Highway proximity and black carbon from cookstoves as a risk factor for higher blood pressure in rural China

Abstract - Air pollution in China and other parts of Asia poses large health risks and is an important contributor to global climate change. Almost half of Chinese homes use biomass and coal fuels for cooking and heating. China's economic growth and infrastructure development has led to increased emissions from coal-fired power plants and an expanding fleet of motor vehicles. Black carbon (BC) from incomplete biomass and fossil fuel combustion is the most strongly light-absorbing component of particulate matter (PM) air pollution and the second most important climate-forcing human emission. PM composition and sources may also be related to its human health impact. We enrolled 280 women living in a rural area of northwestern Yunnan where biomass fuels are commonly used. We measured their blood pressure, distance from major traffic routes, and daily exposure to BC (pyrolytic biomass combustion), water-soluble organic aerosol (organic aerosol from biomass combustion), and, in a subset, hopane markers (motor vehicle emissions) in winter and summer. BC had the strongest association with systolic blood pressure (SBP) (4.3 mmHg; $P < 0.001$), followed by PM mass and water-soluble organic mass. The effect of BC on SBP was almost three times greater in women living near the highway [6.2 mmHg; 95% confidence interval (CI), 3.6 to 8.9 vs. 2.6 mmHg; 95% CI, 0.1 to 5.2]. Our findings suggest that BC from combustion emissions is more strongly associated with blood pressure than PM mass, and that BC's health effects may be larger among women living near a highway and with greater exposure to motor vehicle emissions.

Baumgartnera, J., Y. Zhangc, J. J. Schauerd, W. Huangc, Y. Wangc, & M. Ezzati (2014) Highway proximity and black carbon from cookstoves as a risk factor for higher blood pressure in rural China, PNAS 11(36):13229-13234.

Health effects of multi-pollutant profiles

Abstract — Background - The association between exposure to particle mass and mortality is well established; however, there are still uncertainties as to whether certain chemical components are more harmful than others. Moreover, understanding the health effects associated with exposure to pollutant mixtures may lead to new regulatory strategies. Objectives - Recently we have introduced a new approach that uses cluster analysis to identify distinct air pollutant mixtures by classifying days into groups based on their pollutant concentration profiles. In Boston during the years 1999–2009, we examined whether the effect of PM2.5 on total mortality differed by distinct pollution mixtures. Methods - We applied a time series analysis to examine the association of PM2.5 with daily deaths. Subsequently, we included an interaction term between PM2.5 and the pollution mixture clusters. Results - We found a 1.1% increase (95% CI: 0.0, 2.2) and 2.3% increase (95% CI: 0.9–3.7) in total mortality for a 10 μg/m3 increase in the same day and the two-day average of PM2.5 respectively. The association is larger in a cluster characterized by high concentrations of the elements related to primary traffic pollution and oil combustion emissions with a 3.7% increase (95% CI: 0.4, 7.1) in total mortality, per 10 μg/m3 increase in the same day average of PM2.5. Conclusions - Our study shows a higher association of PM2.5 on total mortality during days with a strong contribution of traffic emissions, and fuel oil combustion. Our proposed method to create multi-pollutant profiles is robust,

and provides a promising tool to identify multi-pollutant mixtures which can be linked to the health effects.

Zanobetti, A., E. Austin, B. A. Coull, J. Schwartz, & P. Koutrakis (2014) Health effects of multi-pollutant profiles, ENVIRONMENT INTERNATIONAL 71:13-19.

Short term association between ambient air pollution and mortality and modification by temperature in five Indian cities

Abstract - Indian cities are among the most polluted areas globally, yet assessments of short term mortality impacts due to pollution have been limited. Furthermore, studies examining temperature – pollution interactions on mortality are largely absent. Addressing this gap remains important in providing research evidence to better link health outcomes and air quality standards for India. Daily all-cause mortality, temperature, humidity and particulate matter less than 10 microns (PM10) data were collected for five cities – Ahmedabad, Bangalore, Hyderabad, Mumbai and Shimla spanning 2005–2012. Poisson regression models were developed to study short term impacts of PM10 as well as temperature – pollution interactions on daily all-cause mortality. We find that excess risk of mortality associated with a 10 μg/m3 PM10 increase is highest for Shimla (1.36%, 95% CI = 0.38%–3.1%) and the least for Ahmedabad (0.16%, 95% CI = 0.31%–0.62%). The corresponding values for Bangalore, Hyderabad and Mumbai are 0.22% (0.04%–0.49%), 0.85% (0.06%–1.63%) and 0.2% (0.1%–0.3%) respectively. The relative health benefits of reducing pollution are higher for cleaner cities (Shimla) as opposed to dirtier cities (Mumbai). Overall we find that temperature and pollution interactions do not significantly impact mortality for the cities studied. This is one of the first multi-city studies that assess heterogeneity of air pollution impacts and possible modification due to temperature in Indian cities that are spread across climatic regions and topographies. Our findings highlight the need for pursuing stringent pollution control policies in Indian cities to minimize health impacts.

Dholakia, H. H., D. Bhadra, & A. Garg (2014) Short term association between ambient air pollution and mortality and modification by temperature in five Indian cities, ATMOSPHERIC ENVIRONMENT 99:168-174.

Health risks of climate change: act now or pay later

Intro - There is growing scientific consensus that climate change is happening, is largely human induced, and will have serious consequences for human health. The impact of climate change on global health is probably not yet large, compared with major risk factors, but will become greater later in this century, especially if the world follows one of the so-called high-end emission pathways, such as Representative Concentration Pathway (RCP) 8 5, outlined in the UN Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report.

Haines, A., K. L Ebi, K. R Smith, & A. Woodward (2014) Health risks of climate change: act now or pay later, THE LANCET 384(9948):20-26.

Domestic airborne black carbon levels and 8-isoprostane in exhaled breath condensate among children in New York City

Abstract – Background - Exposure to airborne black carbon (BC) has been associated with asthma development, respiratory symptoms and decrements in lung function. However, the mechanism through which BC may lead to respiratory symptoms has not been completely elucidated. Oxidative stress has been suggested as a potential mechanism through which BC might lead to adverse health outcomes. Exhaled breath condensate (EBC) allows for the non-invasive collection of airway lining fluid containing biomarkers of oxidative stress like 8-isoprostane, a stable by-product of lipid peroxidation. Therefore, we sought to characterize the association between domestic airborne BC concentrations and 8-isoprostane in EBC. Materials and methods - Seven- and eight-year-old children participated in an asthma case–control study in New York City. During home visits, air samples and EBC were collected. Seven day averages of domestic levels of particulate matter <2.5 μm (PM2.5), BC and environmental tobacco smoke (ETS) were measured. Urea and 8-isoprostane were measured by liquid chromatography tandem mass spectrometry (LC/MS/MS) in EBC. Results - In univariate models,

PM2.5 and BC, but not ETS, were significantly associated with increases in 8-isoprostane in the EBC (β=0.006 and β=0.106 respectively, p<0.05 for both). These associations remained statistically significant for both PM2.5 and BC after adjustment for covariates. In a co-pollutant model including PM2.5, BC and ETS, only BC remained a statistically significant predictor of 8-isoprostane (p<0.05). Conclusions - Our findings suggest the BC fraction of PM might contain exposure relevant to increased oxidative stress in the airways.

Rosa, M. J., B. Yan, S. N. Chillrud, L. M. Acosta, A. Divjan, J. S. Jacobson, R. L. Miller, I. F. Goldstein, & M. S. Perzanowski (2014) Domestic airborne black carbon levels and 8-isoprostane in exhaled breath condensate among children in New York City, ENVIRONMENTAL RESEARCH 135:105-110.

Acute effect of ambient air pollution on heart failure in Guangzhou, China

Abstract – Background - Heart failure (HF) is a global public health problem of increasing importance. The association between acute exposure to air pollution and HF has been well established in developed countries, but little evidence was available in developing countries where air pollution levels were much higher. We conducted a time-series study to investigate the short-term association between air pollution and overall emergency ambulance dispatches (EAD) due to HF in Guangzhou, China. Methods - Daily data of EAD due to HF from 1 January 2008 to 31 December 2012 were obtained from Guangzhou Emergency Center. We applied the over-dispersed Poisson generalized addictive model to analyze the associations after controlling for the seasonality, day of the week and weather conditions. Results - We identified a total of 3375 EAD for HF. A 10-μg/m3 increase in the present-day concentrations of particulate matter with an aerodynamic diameter of less than 10 μm, sulfur dioxide and nitrogen dioxide corresponded to increases of 3.54% [95% confidence interval (CI): 1.35%, 5.74%], 5.29% (95% CI: 2.28%, 8.30%) and 4.34% (95% CI: 1.71%, 6.97%) in daily EAD for HF, respectively. The effects of air pollution on acute HF were restricted on the concurrent day and in the cool seasons. Conclusions - Our results provided the first population-based evidence in Mainland China that outdoor air pollution could trigger the exacerbation of HF.

Yang, C., A. Chen, R. Chen, Y. Qi, J. Ye, S. Li, W. Li, Z. Liang, Q. Liang, D. Guo, H. Kan, & X. Chen (2014) Acute effect of ambient air pollution on heart failure in Guangzhou, China, INTERNATIONAL JOURNAL OF CARDIOLOGY 177(2):436-441.

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AGRICULTURE

Effect of land-use change and management on biogenic volatile organic compound emissions – selecting climate-smart cultivars

Abstract - Land-use change (LUC) has fundamentally altered the form and function of the terrestrial biosphere. Increasing human population, the drive for higher living standards and the potential challenges of mitigating and adapting to global environmental change mean that further changes in LUC are unavoidable. LUC has direct consequences on climate not only via emissions of greenhouse gases and changing the surface energy balance but also by affecting the emission of biogenic volatile organic compounds (BVOCs). Isoprenoids, which dominate global BVOC emissions, are highly reactive and strongly modify atmospheric composition. The effects of LUC on BVOC emissions and related atmospheric chemistry have been largely ignored so far. However, compared with natural ecosystems, most tree species used in bioenergy plantations are strong BVOC emitters, whereas intensively cultivated crops typically emit less BVOCs. Here, we summarize the current knowledge on LUC-driven BVOC emissions and how these might affect atmospheric composition and climate. We further discuss land management and plant-breeding strategies, which could be taken to move towards climate-friendly BVOC emissions while simultaneously maintaining or improving key ecosystem functions such as crop yield under a changing environment.

Rosenkranz, M., T. A. M. Pugh, J. Schnitzler, & A. Arneth (2014) Effect of land-use change and management on biogenic volatile organic compound emissions – selecting climate-smart cultivars, PLANT CELL ENVIRON (early edition).

Biomass from landscape management of grassland used for biogas production: effects of harvest date and silage additives on feedstock quality and methane yield

Abstract - Biogas production from grassland biomass harvested during landscape management may help to maintain species-rich grassland biotopes, but extensive management and late harvests often result in low-quality biomass. Biogas production from the vegetation of Alopecuretum pratensis, Molinietum caeruleae and Caricetum gracilis, three typical grassland biotopes in north German nature reserves, was investigated in relation to harvest date. In addition, the A. pratensis vegetation was investigated for ensiling and the application of bacterial silage additives. Results indicate that biogas production might be a reasonable utilization pathway for grassland biomass from landscape management if the first cut occurs up to late summer. Methane yields of grassland biomass decreased substantially with later harvest, from up to 309 lN kg 1 organic dry matter (ODM) in May to below 60 lN kg 1 ODM in February, in correlation with increasing crude fibre contents. Caricetum gracilis vegetation was the least suitable feedstock for biogas production. It showed a rapid decline in methane yields with later harvest and 25% lower methane yields compared with other types of grassland vegetation. Application of silage additives is recommended for adequate preservation of grassland biomass from landscape management by ensiling. Addition of homofermentative lactic acid bacteria improved acidification during ensiling if sufficient fermentable sugar was available. The use of inoculant and molasses enhanced methane yields by 3–55%. Additional carbohydrate source is necessary to ensure proper ensilage when grasses are harvested after late autumn.

Herrmann, C., A. Prochnow, M. Heiermann, & C. Idler (2014) Biomass from landscape management of grassland used for biogas production: effects of harvest date and silage additives on feedstock quality and methane yield, GRASS & FORAGE SCIENCE 69(4):549-566.

Effects of elevated ozone concentration on CH4 and N2O emission from paddy soil under fully open-air field conditions

Abstract – We investigated the effects of elevated ozone concentration (E-O3) on CH4 and N2O emission from paddies with two rice cultivars: an inbred Indica cultivar Yangdao 6 (YD6) and a hybrid one II-you 084 (IIY084), under fully open-air field conditions in China. A mean 26.7% enhancement of ozone concentration above the ambient level (A-O3) significantly reduced CH4 emission at tillering and flowering stages leading to a reduction of seasonal integral CH4 emission by 29.6% on average across the two cultivars. The reduced CH4 emission is associated with O3-induced reduction in the whole-plant biomass (-13.2%), root biomass (-34.7%) and maximum tiller number (-10.3%), all of which curbed the carbon supply for below-ground CH4 production and its release from submerged soil to atmosphere. Although no significant difference was detected between the cultivars in the CH4 emission response to E-O3, a larger decrease in CH4 emission with IIY084 (-33.2%) than that with YD6 (-7.0%) was observed at tillering stage, which may be due to the larger reduction in tiller number in IIY084 by E-O3. Additionally, E-O3 reduced seasonal mean NOx flux by 5.7% and 11.8% with IIY084 and YD6, respectively, but the effects were not significant statistically. We found that the relative response of CH4 emission to E-O3 was not significantly different from those reported in open-top chamber experiments. This study has thus confirmed that increasing ozone concentration would mitigate the global warming potential of CH4, and suggested consideration of the feedback mechanism between ozone and its precursor emission into the projection of future ozone effects on terrestrial ecosystem.

Tang, H., G. Liu, J. Zhu, & K. Kobayashi (2014) Effects of elevated ozone concentration on CH4 and N2O emission from paddy soil under fully open-air field conditions, GLOBAL CHANGE BIOLOGY (Accepted Manuscript).

Kinetics of temperature effects and its significance to the heating strategy for anaerobic digestion of swine wastewater

Abstract - The effects of temperature on biogas production and the heating strategy for anaerobic digestion of swine wastewater were investigated. Through a kinetic model, the maximum volumetric rate of biogas production (Rpmax) for digestion at 15, 20, 25, 30, and 35 C were found to be 0.282, 1.189, 1.464, 1.789, and 2.049 L L 1 d 1, respectively. The temperature–activity coefficient of Rpmax was 1.332 at 15–20 C, 1.043 at 20–25 C, 1.041 at 25–30 C, and 1.028 at 30–35 C. Anaerobic digestion appeared to be more sensitive to temperature variation within 15–20 C than to variation within 20–35 C. In terms of energy input–output ratio and total annual cost, the optimal heating strategy is an increase in the fermentation temperature from 15 to 20 C.

Deng, L., H. Yang, G. Liu, D. Zheng, Z. Chen, Y. Liu, X. Pu, L. Song, Z. Wang, & Y. Lei (2014) Kinetics of temperature effects and its significance to the heating strategy for anaerobic digestion of swine wastewater, APPLIED ENERGY 134:349-355.

Effects of long-term straw incorporation on the net global warming potential and the net economic benefit in a rice–wheat cropping system in China

Abstract - Straw incorporation has multiple effects on greenhouse gas emissions and soil productivity. However, few studies have comprehensively evaluated the effects of long-term straw incorporation. An ongoing long-term straw incorporation experiment in a rice–wheat cropping system in China was established in 1990 and was used in the present study to evaluate the net global warming potential (NGWP) and the net economic benefit (NEB) of the straw return. The following four field treatments were included: a control (CK); N, P and K fertilization (NPK); fertilization plus a moderate rate of straw application (NPKS1); and fertilization plus a high rate of straw application (NPKS2). We calculated the increase in the soil organic carbon (SOC) and the straw-induced emissions of CH4 and N2O, which were expressed as the global warming potential (GWP) in units of CO2-equivalent (CO2-eq) at the 100-year scale. The straw-induced NEB was defined as the difference between the economic income, which was calculated by multiplying the increase in straw-induced crop grain yield by the grain price, and the economic loss was computed by multiplying the increase in straw-induced CO2-eq emissions by the carbon price. The results showed that long-term straw incorporation significantly increased the CH4 emissions and the topsoil SOC density. The GWP of the straw-induced CH4 emissions was 3.21–3.92 times that of the straw-induced SOC sequestration rate, suggesting that long-term direct straw incorporation in the rice–wheat systems worsens rather than mitigates the climate change. Additionally, continuous straw incorporation slightly enhanced the rice and wheat grain yields, contributing to the production of the NEB. We determined that under the current carbon price, ranging from 2.55 to 31.71 EUR per ton CO2-eq, the direct straw incorporation will produce a positive NEB, ranging from 156 to 658 RMB ha 1 year 1, if the grain yield prices do not fluctuate, which does not provide a significant incentive for farmers to change from their traditional direct straw incorporation pattern. Considering the other benefits that the straw application produced, such as improving soil fertility and the water retention capacity, we recommend that the government should establish an incentive for ecological compensation to encourage farmers to implement proper straw incorporation, such as composting straw under aerobic conditions before application.

Xia, L., S. Wang, & X. Yan (2014) Effects of long-term straw incorporation on the net global warming potential and the net economic benefit in a rice–wheat cropping system in China, AGRICULTURE, ECOSYSTEMS & ENVIRONMENT 197:118-127.

The inclusion of forage mixtures in the diet of growing dairy heifers: Impacts on digestion, energy utilisation, and methane emissions

Hammond, K. J., D. J. Humphries, D. B. Westbury, A. Thompson, L.A. Crompton, P. Kirton, C. Green, & C. K. Reynolds (2014) The inclusion of forage mixtures in the diet of growing dairy heifers: Impacts on digestion, energy utilisation, and methane emissions, AGRICULTURE, ECOSYSTEMS & ENVIRONMENT 197:88-95.

Abstract - Intensive farming focusing on monoculture grass species to maximise forage production has led to a reduction in the extent and diversity of species-rich grasslands. However, plant communities with higher species number (richness) are a potential strategy for more sustainable production and mitigation of greenhouse gas (GHG) emissions. Research has indicated the need to understand opportunities that forage mixtures can offer sustainable ruminant production systems. The objective of the two experiments reported here were to evaluate multiple species forage mixtures in comparison to ryegrass-dominant pasture, when conserved or grazed, on digestion, energy utilisation, N excretion, and methane emissions by growing 10–15 month old heifers. Experiment 1 was a 4 4 Latin square design with five week periods. Four forage treatments of: (1) ryegrass (control); permanent pasture with perennial ryegrass (Lolium perenne); (2) clover; a ryegrass:red clover (Trifolium pratense) mixture; (3) trefoil; a ryegrass:birdsfoot trefoil (Lotus corniculatus) mixture; and (4) flowers; a ryegrass:wild flower mixture of predominately sorrel (Rumex acetosa), ox-eye daisy (Leucanthemum vulgare), yarrow (Achillea millefolium), knapweed (Centaurea nigra) and ribwort plantain (Plantago lanceolata), were fed as haylages to four dairy heifers. Measurements included digestibility, N excretion, and energy utilisation (including methane emissions measured in respiration chambers). Experiment 2 used 12 different dairy heifers grazing three of the same forage treatments used to make haylage in experiment 1 (ryegrass, clover and flowers) and methane emissions were estimated using the sulphur hexafluoride (SF6) tracer technique. Distribution of ryegrass to other species (dry matter (DM) basis) was approximately 70:30 (clover), 80:20 (trefoil), and 40:60 (flowers) for experiment 1. During the first and second grazing rotations (respectively) in experiment 2, perennial ryegrass accounted for 95 and 98% of DM in ryegrass, and 84 and 52% of DM in clover, with red clover accounting for almost all of the remainder. In the flowers mixture, perennial ryegrass was 52% of the DM in the first grazing rotation and only 30% in the second, with a variety of other flower species occupying the remainder. Across both experiments, compared to the forage mixtures (clover, trefoil and flowers), ryegrass had a higher crude protein (CP) content (P < 0.001, 187 vs. 115 g kg 1 DM) and DM intake (P < 0.05, 9.0 vs. 8.1 kg day 1). Heifers in experiment 1 fed ryegrass, compared to the forage mixtures, had greater total tract digestibility (g kg 1) of DM (DMD; P < 0.008, 713 vs. 641) and CP (CPD, P < 0.001, 699 vs. 475), and used more intake energy (%) for body tissue deposition (P < 0.05, 2.6 vs. 4.9). For both experiments, heifers fed flowers differed the most compared to the ryegrass control for a number of measurements. Compared to ryegrass, flowers had 40% lower CP content (P < 0.001, 113 vs. 187 g kg 1), 18% lower DMD (P < 0.01, 585 vs. 713 g kg 1), 42% lower CPD (P < 0.001, 407 vs. 699 g kg 1), and 10% lower methane yield (P < 0.05, 22.6 vs. 25.1 g kg 1 DM intake). This study has shown inclusion of flowers in forage mixtures resulted in a lower CP concentration, digestibility and intake. These differences were due in part to sward management and maturity at harvest. Further research is needed to determine how best to exploit the potential environmental benefits of forage mixtures in sustainable ruminant production systems.

Comparison of methane emission characteristics in air-dried and composted cattle manure amended paddy soil during rice cultivation

Abstract - Application of organic matter is essential for sustaining the health and productivity of a soil. However, organic amendments produce methane (CH4) emissions from rice (Oryza sativa L.) paddy soils. In this experiment, we evaluated the relative effects of composted and air-dried forms of different manures on CH4 emission from rice paddy soils. Air-dried and composted manures from both Korean cows and dairy cows were applied to evaluate their effects on CH4 emissions in rice paddy soils. Application of organic amendments increased CH4 emissions from soil during rice cultivation. Application of composted manures reduced CH4 emission by up to 50% compared to air-dried manures. The chemical composition of applied cattle manures may also determine the level of CH4 emissions from rice paddy soils. The amount of decomposable organic C, its distribution in lighter soil aggregates and the potential of these soil aggregates to generate labile C compounds in soil were possible influencing factors in the emission of CH4 from organic amended rice paddy soils.

Kim, S. Y., P. Pramanik, J. Gutierrez, H. Y. Hwang, & P. J. Kim (2014) Comparison of methane emission characteristics in air-dried and composted cattle manure amended paddy soil during rice cultivation, AGRICULTURE, ECOSYSTEMS & ENVIRONMENT 197:60-67.

Life cycle greenhouse gas emissions in California rice production

Abstract - The nexus of climate change and food security challenges currently facing humanity requires better understanding of how to balance food production needs with climate change mitigation. Life cycle assessment methods provide a way to quantify the climate impacts of a food product by accounting for all greenhouse gas (GHG) emissions associated with its production, including upstream and downstream from the farm. This study modeled life cycle GHG emissions for one kg of milled, unpackaged rice produced in California, USA, a state that achieves some of the highest rice yields in the world. The goal was to (1) provide an assessment of life cycle GHG emissions of a comparatively intensive production system, using local field emissions data, (2) identify emissions hotspots, and (3) create a model that elucidates the life cycle-wide consequences of potential changes in field management practices. Study parameters are based on an annual cropping cycle, with continuous flooding during the growing season and soil incorporation of straw post-harvest, and yields of 9.3 Mt ha 1 dried paddy rice. Field emissions (growing and fallow seasons) were estimated with empirical data while other emissions were calculated using an engineering model coupled with life cycle inventory datasets and vehicle emission models.

The 100-year global warming potential (GWP, based on CO2, CH4 and N2O) was 1.47 kg CO2-equivalent (CO2e) kg 1 of milled rice; of which field emissions contributed 69%. These results are relatively low when compared to life cycle studies in other parts of the world, due in large part to higher grain yields and lower field emissions. When using IPCC Tier 1 estimates of field emissions, the GWP increased to 3.60 CO2e kg 1 rice, highlighting the importance of using direct field measurements as we have in this study. Due to their large contributions to life cycle GWP, reducing field CH4 emissions through different field management practices, optimizing N fertilizer use, and increasing fuel efficiency or reducing use of farm machinery present the greatest opportunities to reduce life cycle emissions. Because of high variability and uncertainty in estimating field emissions, they should also be targeted for improved measurement and modeling.

Brodt, S., A. Kendall, Y. Mohammadi, A. Arslan, J. Yuan, I. Lee, & B. Linquist (2014) Life cycle greenhouse gas emissions in California rice production, FIELD CROPS RESEARCH 169:89-98.

Metrics and indices to assess the life cycle costs and greenhouse gas impacts of a dairy digester

Abstract - This paper aims to propose consistent Life Cycle Assessment and Life Cycle Costing metrics and indices and to test them to assess an anaerobic digester on a dairy farm. The method is based on a graphic representation of the environmental Life Cycle Impact and economic Life Cycle Cost Differentials. Performance indices are the Internal Rate of Return (discount rate that makes the total cost differential over the lifetime equal to zero), the Breakeven Price of Electricity (unit price of electricity that makes the total cost differential over the life time equal to zero) and the Impact Savings Ratio (the total impact reduction divided by the detrimental impacts generated). A dairy digester producing electricity, chosen as case study yields a substantial carbon footprint reduction close to 0.2 kg CO2e per liter of milk (25% improvement of milk carbon footprint), corresponding to a high Impact Savings Ratio of 34–37. Life Cycle Cost Differentials ranges from $545 (most favorable) to $808 (least favorable) per cow, depending on electricity price, heat recovery and upfront grant. Economic performances are reflected in the Internal Rates of Return (IRR), that range from 1% to 12%. The Breakeven Price of Electricity ranges from $0.07 to $0.13 per kWh. The effective economic performance is measured by choosing the discount rate equal to the Weighted Average Cost of Capital of the stakeholder. Comparing the IRR to his target rate of return enables the decision maker to check whether its own economic targets are met.

Asselin-Balençon, A. C., & O. Jolliet (2015) Metrics and indices to assess the life cycle costs and greenhouse gas impacts of a dairy digester, JOURNAL OF CLEANER PRODUCTION 79:98-107.

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Downwind O3 and PM2.5 speciation during the wildfires in 2002 and 2010

Abstract - A series of wildfires in northern Quebec, early July 2002, and in southern Quebec, late May 2010, resulted in severe air pollution downwind. Downwind exposures were investigated to estimate the impact on outdoor and indoor environments. The plumes derived from the wildfires resulted in an increase of over 10 ppbv ozone (O3) concentrations in both major cities and rural areas, while O3 enhancement was not observed at locations adjacent to wildfire burning areas. Temporal trend in PM2.5 concentration showed a peak of 105.5 μg/m3 on July 7, 2002, while on May 31, 2010 the peak was 151.1 μg/m3 in Boston downwind. PM2.5 speciation showed similar trends between the episodes, along with spikes in the PM2.5/PM10 ratio, and in the concentrations of Black Carbon, ΔC (i.e., UV absorbing compounds minus Black Carbon), Organic Carbon (OC), potassium, and chlorine. OC was the most dominant constituent of the PM2.5 mass in the wildfires. The dominant specific carbon fractions include OC fraction 3, pyrolysis carbon, and EC fraction 1, likely due to pyrolysis of structural components of wood. Indoor PM2.5 peaks at two houses corresponded well with the ambient PM2.5 peak, along with the elemental composition, which could indicate an impact of wildfires on indoor air pollution exposure.

Kang, C.-M., D. Gold, & P. Koutrakis (2014) Downwind O3 and PM2.5 speciation during the wildfires in 2002 and 2010, ATMOSPHERIC ENVIRONMENT 95:511-519.

Pre-harvest sugarcane burning emission inventories based on remote sensing data in the state of São Paulo, Brazil

Abstract - The state of São Paulo is the largest sugarcane producer in Brazil, with a cultivated area of about 5.4 Mha in 2011. Approximately 2 Mha were harvested annually from 2006 to 2011 with the pre-harvest straw burning practice, which emits trace gases and particulate material to the atmosphere. The development of emission inventories for sugarcane straw burning is crucial in order to assess its environmental impacts. This study aimed to estimate annual emissions associated with the pre-harvest sugarcane burning practice in the state of São Paulo based on remote sensing maps and emission and combustion factors for sugarcane straw burning. Average estimated emissions (Gg/year) were 1130 152 for CO, 26 4 for NOx, 16 2 for CH4, 45 6 for PM2.5, 120 16 for PM10 and 154 21 for NMHC (non-methane hydrocarbons). An intercomparison among annual emissions from this study and annual emissions from four other different approaches indicated that the estimates obtained by satellite fire detection or low spatial resolution approaches tend to underestimate sugarcane burned area, due to unique characteristics of this type of biomass fire. Overall, our results also indicated that government actions to reduce sugarcane straw burning emissions are becoming effective.

França, D., K. Longo, B. Rudorff, D. Aguiar, S. Freitas, R. Stockler, & G. Pereira (2014) Pre-harvest sugarcane burning emission inventories based on remote sensing data in the state of São Paulo, Brazil, ATMOSPHERIC ENVIRONMENT 99:446-456.

Biomass burning contribution to ambient volatile organic compounds (VOCs) in the Chengdu–Chongqing Region (CCR), China

Abstract - Ambient volatile organic compounds (VOCs) were measured intensively using an online gas chromatography–mass spectrometry/flame ionization detector (GC–MS/FID) at Ziyang in the Chengdu–Chongqing Region (CCR) from 6 December 2012 to 4 January 2013. Alkanes contributed the most (59%) to mixing ratios of measured non-methane hydrocarbons (NMHCs), while aromatics contributed the least (7%). Methanol was the most abundant oxygenated VOC (OVOC), contributing 42% to the total amount of OVOCs. Significantly elevated VOC levels occurred during three pollution events, but the chemical composition of VOCs did not differ between polluted and clean days. The OH loss rates of VOCs were calculated to estimate their chemical reactivity. Alkenes played a predominant role in VOC reactivity, among which ethylene and propene were the largest contributors; the contributions of formaldehyde and acetaldehyde were also considerable. Biomass

burning had a significant influence on ambient VOCs during our study. We chose acetonitrile as a tracer and used enhancement ratio to estimate the contribution of biomass burning to ambient VOCs. Biomass burning contributed 9.4%–36.8% to the mixing ratios of selected VOC species, and contributed most (>30% each) to aromatics, formaldehyde, and acetaldehyde.

Li, L., Y. Chen, L. Zeng, M. Shao, S. Xie, W. Chen, S. Lu, Y. Wu, & W. Cao (2014) Biomass burning contribution to ambient volatile organic compounds (VOCs) in the Chengdu–Chongqing Region (CCR), China, ATMOSPHERIC ENVIRONMENT 99:403-410.

Time-dependent climate impact of heat production from Swedish willow and poplar pellets – In a life cycle perspective

Abstract - Sweden has the potential to increase fuel pellet production from alternative raw materials, such as willow and poplar, and also to use former agricultural land for energy crop production. This study used a life cycle perspective to investigate district heat production from pellets produced from willow or poplar cultivated on fallow land in Sweden. The energy efficiency and global warming potential of the systems was evaluated, additionally was the climate impact, expressed in global mean surface temperature change, evaluated from annual greenhouse gas data, including the most relevant fossil and biogenic sources and sinks. The systems were also compared with a fossil fuel alternative in which coal was assumed to be used for heat production. The results showed that the systems investigated had a cooling effect on both global mean surface temperature and global warming potential within the 100-year study period owing mainly to an increase in live biomass and a more long-term increase in soil organic carbon (C), which shows the importance of land use. At the same time, the systems produced renewable energy. The poplar system contributed to a larger cooling effect than the willow system due to more C being sequestered in live biomass and soil in the longer growth periods between harvests and to higher yield. The energy efficiency of the willow and poplar systems used for pellet fuel production was about 11 times the energy input.

Porsö, C., & P. Hansson (2014) Time-dependent climate impact of heat production from Swedish willow and poplar pellets – In a life cycle perspective, BIOMASS AND BIOENERGY 70:287-301.

Impact of forest biomass residues to the energy supply chain on regional air quality

Abstract - The increase of the share of renewable energy in Portugal can be met from different sources, of which forest biomass residues (FBR) can play a main role. Taking into account the demand for information about the strategy of FBR to energy, and its implications on the Portuguese climate policy, the impact of energy conversion of FBR on air quality is evaluated. Three emission scenarios were defined and a numerical air quality model was selected to perform this evaluation. The results reveal that the biomass thermal plants contribute to an increment of the pollutant concentrations in the atmosphere, however restricted to the surrounding areas of the thermal plants, and most significant for NO2 and O3.

Rafael, S., L. Tarelho, A. Monteiro, E. Sá, A.I. Miranda, C. Borrego, & M. Lopes (2014) Impact of forest biomass residues to the energy supply chain on regional air quality, SCIENCE OF THE TOTAL ENVIRONMENT 505:640-648.

Fire risk, atmospheric chemistry and radiative forcing assessment of wildfires in eastern Mediterranean

Abstract - The current research study aims at investigating the atmospheric implications of a major fire event in the Mediterranean area. For this purpose, a regional aerosol model coupled online with meteorology (COSMO-ART) is applied over Greece during late summer 2007. Fire risk model results proved to be adequate in reproducing the highly destructive event, which supports further applications for national meteorological forecasts and early warning systems for fire prevention. Columnar aerosol loading field predictions are consistent with satellite maps, which further allows for the correlation of this wildfire event to the atmospheric chemistry and the radiative forcing. Gaseous chemistry resembles that in urban environments and led to nitrogen dioxide and ozone exceedances in several cities in proximity to and downwind the fire spots, respectively. Influence in Athens is

found significant from the Euboean plume (45% of total surface PM10) and small (5%) from the fires in Peloponnese. Fire events are indicated by sharp increases in organic to elemental carbon (6), together with sharp decreases in secondary to total organic components (0.1), in comparison to their values during the pre- and post-fire period over Athens (1 and 0.6, respectively). The change in the radiative budget induced by the fire plume is found negative (3-day-average value up to 10 W m 2). Direct heat input is found negligible, thus the net temperature effect is also negative over land (0.5 K). Nevertheless, positive temperature changes are found overseas (hourly value up to +2 K), due to the amplified radiation absorption by aged soot, coupled to the intense stabilization of the atmosphere above the sea surface.

Athanasopoulou, E., D. Rieger, C. Walter, H. Vogel, A. Karali, M. Hatzaki, E. Gerasopoulos, B. Vogel, C. Giannakopoulos, M. Gratsea, & A. Roussos (2014) Fire risk, atmospheric chemistry and radiative forcing assessment of wildfires in eastern Mediterranean, ATMOSPHERIC ENVIRONMENT 95:113-125.

Trace gas and particle emissions from open burning of three cereal crop residues: Increase in residue moistness enhances emissions of carbon monoxide, methane, and particulate organic carbon

Abstract - We determined emission factors for open burning of straw of rice, wheat, and barley, as well as rice husks, and we incorporated the effects of moisture content on the emission factors for the straw. A closed system that simulated on-site backfiring of residues on the soil surface under moderate wind conditions was used to measure the gas and particle emissions from open burning of the residues on an upland field. Two moisture content conditions were evaluated: a dry condition (air-dried residues, 11–13% by weight) and a moist condition (20%). When a linear regression model with the initial moisture content of the residue as the explanatory variable showed good correlation between the primary emission data of a substance and the moisture content, the regression model was adopted as a function to give the emission factors. Otherwise, the unmodified primary data were used as the emission factors. The magnitudes of the gas and particle emissions differed among the residue types. For example, carbon monoxide (CO) emissions from straw of rice, wheat, and barley and rice husks burned under the dry condition were 27.2 1.7, 41.8 24.2, 46.9 2.1, and 66.1 g kg 1 dry matter, and emissions of methane (CH4) were 0.75 0.01, 2.01 0.93, 1.47 0.06, and 5.81 g kg 1 dry matter, respectively (n = 2 for straw with the standard deviation; n = 1 for husks). Emissions of carbon-containing gases and particles (e.g., CO, CH4, and particulate organic carbon) were higher under the moist condition than under the dry condition, which suggests that emission factors for open burning should incorporate the effects of moisture content except open burning performed in the dry season or arid zones.

Hayashi, K., K. Ono, M. Kajiura, S. Sudo, S. Yonemura, A. Fushimi, K. Saitoh, Y. Fujitani, & K. Tanabe (2014) Trace gas and particle emissions from open burning of three cereal crop residues: Increase in residue moistness enhances emissions of carbon monoxide, methane, and particulate organic carbon, ATMOSPHERIC ENVIRONMENT 95:36-44.

Physicochemical characterization of smoke aerosol during large-scale wildfires: Extreme event of August 2010 in Moscow

Abstract - Enhancement of biomass burning-related research is essential for the assessment of large-scale wildfires impact on pollution at regional and global scale. Starting since 6 August 2010 Moscow was covered with thick smoke of unusually high PM10 and BC concentrations, considerably affected by huge forest and peat fires around megacity. This work presents the first comprehensive physico-chemical characterization of aerosols during extreme smoke event in Moscow in August 2010. Sampling was performed in the Moscow center and suburb as well as one year later, in August 2011 during a period when no biomass burning was observed. Small-scale experimental fires of regional biomass were conducted in the Moscow region. Carbon content, functionalities of organic/inorganic compounds, tracers of biomass burning (anhydrosaccharides), ionic composition, and structure of smoke were analyzed by thermal-optical analysis, FTIR spectroscopy, liquid and ion chromatography, and electron microscopy. Carbonaceous aerosol in August 2010 was dominated by organic species with elemental carbon (EC) as minor component. High average OC/EC near 27.4 is found, comparable

to smoke of regional biomass smoldering fire, and exceeded 3 times the value observed in August 2011. Organic functionalities of Moscow smoke aerosols were hydroxyl, aliphatic, aromatic, acid and non-acid carbonyl, and nitro compound groups, almost all of them indicate wildfires around city as the source of smoke. The ratio of levoglucosan (LG) to mannosan near 5 confirms the origin of smoke from coniferous forest fires around megacity. Low ratio of LG/OC near 0.8% indicates the degradation of major molecular tracer of biomass burning in urban environment. Total concentration of inorganic ions dominated by sulfates image and ammonium image was found about 5 times higher during large-scale wildfires than in August 2011. Together with strong sulfate and ammonium absorbance in smoke aerosols, these observations prove the formation of secondary inorganic species associated with wildfire gaseous emissions and their transformation in aged smoke. Accumulation of carbonyl compounds during extreme smoke event in Moscow resulted from photochemical aging and secondary organic aerosol (SOA) formation in the urban atmosphere. The mixture of carbonaceous particles and dust revealed multicomponent structure of Moscow smoke aerosols, pointing the difference with non-smoke ambient aerosols. The abundance of group containing soot and tar balls approached at least a half of total aerosol concentration during extreme event, relating to elevated OC, EC and SOA. Fly ash groups contained calcium sulfates and carbonates from soil entrainment by hot air convection. Small-scale open fire experiments support the identification of specific chemical features of regional biomass burning and demonstrate the strong impact of large-scale wildfires on aerosol chemistry and air quality in highly polluted megacity.

Popovicheva, O., M. Kistler, E. Kireeva, N. Persiantseva, M. Timofeev, V. Kopeikin, & A. Kasper-Giebl (2014) Physicochemical characterization of smoke aerosol during large-scale wildfires: Extreme event of August 2010 in Moscow, ATMOSPHERIC ENVIRONMENT 96:405-414.

Physicochemical characterization of aged biomass burning aerosol after long-range transport to Greece from large scale wildfires in Russia and surrounding regions, Summer 2010

Abstract - Smoke aerosol emitted by large scale wildfires in the European part of Russia and Ukraine, was transported to Athens, Greece during August 2010 and detected at an urban background site. Measurements were conducted for physico-chemical characterization of the aged aerosol and included on-line monitoring of PM10 and carbonaceous particles mass concentrations, as well as number size distributions and aerosol optical properties. In addition TSP filter samples were analyzed for major inorganic ions, while morphology and composition of particles was studied by individual particle analysis. Results supported the long-range transport of smoke plumes from Ukraine and Russia burning areas indicated by back trajectory analysis. An increase of 50% and 40% on average in organic (OC) and elemental carbon (EC) concentrations respectively, and more than 95% in carbonate carbon (CC) levels was observed for the biomass burning (BB) transport period of August with respect to the previous month of July. Mean 24-h OC/EC ratio was found in the range 3.2–8.5. Single scattering albedo (SSA) was also increased, indicating abundance of light scattering constituents and/or shift of size distributions towards larger particles. Increase in particle size was further supported by a decreasing trend in absorption Angström exponent (AAE). Ion analysis showed major contribution of secondary species (ammonium sulfate and nitrate) and soil components (Ca2+, Mg2+). Non-sea salt K+ exhibited very good correlation with secondary species, indicating the long-range transport of BB smoke as a possible common source. Individual particle analysis of the samples collected during BB-transport event in Athens revealed elevated number of soot externally mixed with fly ash Ca-rich particles. This result is in agreement with the increased OC and CC levels measured, thus pointing towards the main components comprising the aged BB aerosol microstructure.

Diapouli, E., O. Popovicheva, M. Kistler, S. Vratolis, N. Persiantseva, M. Timofeev, A. Kasper-Giebl, & K. Eleftheriadis (2014) Physicochemical characterization of aged biomass burning aerosol after long-range transport to Greece from large scale wildfires in Russia and surrounding regions, Summer 2010, ATMOSPHERIC ENVIRONMENT 96:393-404.

Methane emission inventories for enteric fermentation and manure management of yak, buffalo and dairy and beef cattle in China from 1988 to 2009

Abstract - Large ruminant production systems (dairy, beef, buffaloes and yaks) in China have experienced significant changes during the last 30 years driven by increased demand for milk and meat consumption and discontinued use of beef cattle and buffaloes as draft animals. The present study aimed to evaluate the effects of these changes on methane (CH4) emissions from enteric fermentation and manure management in large ruminants in China. The emissions were developed using Tier 1 and 2 methodologies of the International Panel on Climate Change. The Tier 2CH4 emission for each species was a sum of emissions calculated from several groups based on their physiological states, e.g. milking cows, dry cows, sires and steers/heifers at various ages. Total CH4 emission inventory for dairy cattle, beef cattle, buffaloes and yaks in China increased gradually from 5530 to 6761 Gg/year or 4514 to 5777 Gg/year calculated using the Tier 1 or 2 method during the period of 1988–2009. This increase was driven by increased population and production of dairy and beef cattle (e.g. Tier 2CH4 emissions increased respectively from 125 to 1028 Gg/year and from 2915 to 3689 Gg/year). However, during the same period Tier 2CH4 emissions from buffaloes and yaks reduced from 860 to 593 Gg/year and 614 to 467 Gg/year, respectively. Beef cattle were main emitters which produced 63.8% of total emissions in 2009, followed by dairy cattle (17.8%), buffaloes (10.3%) and yaks (8.1%). There was a large difference in provincial contributions. In 2007, the 3 highest emission provinces (Sichuan, Tibet and Henan) each contributed 8.5–10.5% to national emissions, and the lowest 3 accounted for only 0.1–0.2% (Beijing, Zhejiang and Shanghai). The uncertainties associated with these inventories were discussed. These results provide benchmark information for Chinese authorities to develop appropriate policies and mitigation strategies to reduce carbon footprint in the large ruminant production sector in China.

Xue, B., L. Z. Wang, & T. Yan (2014) Methane emission inventories for enteric fermentation and manure management of yak, buffalo and dairy and beef cattle in China from 1988 to 2009, AGRICULTURE, ECOSYSTEMS & ENVIRONMENT 195:202-210.

Sustainability of meat production beyond carbon footprint: a synthesis of case studies from grazing systems in Uruguay

Abstract - Livestock production has been challenged as a large contributor to climate change, and carbon footprint has become a widely used measure of cattle environmental impact. This analysis of fifteen beef grazing systems in Uruguay quantifies the range of variation of carbon footprint, and the trade-offs with other relevant environmental variables, using a partial life cycle assessment (LCA) methodology. Using carbon footprint as the primary environmental indicator has several limitations: different metrics (GWP vs. GTP) may lead to different conclusions, carbon sequestration from soils may drastically affect the results, and systems with lower carbon footprint may have higher energy use, soil erosion, nutrient imbalance, pesticide ecotoxicity, and impact on biodiversity. A multidimensional assessment of sustainability of meat production is therefore needed to inform decision makers. There is great potential to improve grazing livestock systems productivity while reducing carbon footprint and other environmental impacts, and conserving biodiversity.

Picasso, V. D., P. D. Modernel, G. Becoña, L. Salvo, L. Gutiérrez, & L. Astigarraga (2014) Sustainability of meat production beyond carbon footprint: a synthesis of case studies from grazing systems in Uruguay, MEAT SCIENCE 98(3):346-354.

The relevance of methane emissions from beef production and the challenges of the Argentinean beef production platform

Abstract - The livestock sector faces the challenge to respond to the growing demand for animal protein from an expanding population while reducing environmental impact through GHG emissions. Globally about 2.836 million tons of CO2-eq were emitted by the beef production sector equivalent to 46,2 kg CO2-eq per kg carcass weight (CW). From the 1.485 million cattle head spread out over the world, 82% are on extensive grazing systems while only 18% are on high productive intensive systems. Among the top ten beef exporter countries, five are located in Latin America accounting a

quarter of the global stock and two of them, Argentina and Uruguay, produce on temperate pastures under grazing systems. In Argentina, the livestock area was reduced in favor of increasing the grain cropping area, which took place in the last two decades. Production systems were intensified to maintain cattle stock. Cattle programs changed from 100% pasture to pasture supplemented with cereal grains and conserved forages, and confinement on grain feeding for fattening was incorporated. Due to land sharing competition with cash crops, no increment of cattle stock is expected therefore improving production efficiency appears as the only way to increase beef production while reducing methane emissions intensity. Beef produced on intensive grazing systems on supplemented pastures maintained organoleptic, nutritional and lipid profile than that of beef produced on pure grazing systems.

XXXX (2014) The relevance of methane emissions from beef production and the challenges of the Argentinean beef production platform, MEAT SCIENCE 98(3):355-360.

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WASTE

Numerical simulation of dynamic processes of the methane migration and oxidation in landfill cover

Abstract - The coupling model of the multicomponent gas flow and transport was developed to describe methane oxidation in landfill cover. A two-part simulation was carried out to investigate the dynamic processes of methane oxidation. The reliability of the coupling model was validated by comparing the simulated data on gas concentrations with the measured data. To evaluate the influence of the pumping well on the oxidation reaction, methane emission throughout the landfill cover was simulated. Methane oxidation in the landfill cover demonstrated dynamic characteristics. The results suggest that the oxidation effect is closely related to methane emission. Sensitivity parameters were also introduced to determine the maximum oxidation rate and permeability. The critical targets of the reduction rate and reduction volume of methane were analyzed based on 20 years' worth of pumping operation data. The result further illustrates the dynamic behavior of methane oxidation, which is influenced by the degree of methanotrophic reaction and the balance between methane and air influx in the landfill cover. The results highlight the significance of the study in quantitatively assessing the capacity of landfill covers to reduce methane emissions in landfills.

Lei, L., X. Qiang, X. Yue, Y. Fu, & Z. Ying (2014) Numerical simulation of dynamic processes of the methane migration and oxidation in landfill cover, ENVIRONMENTAL PROGRESS & SUSTAINABLE ENERGY 33(4):1419-1424.

Life cycle assessment of different municipal solid waste management options: a case study of Asturias (Spain)

Abstract - This paper analyses six strategies for managing the MSW generated in Asturias (Spain) in terms of their environmental impacts applying the Life Cycle Analysis methodology. To this end, the effect of these strategies on Human Health, Ecosystem Quality, Global Warming and Resource Depletion is studied. The analysed management options include direct landfill with recovery of biogas (S-0), direct incineration with energy recovery (S-1), biomethanization of the source-separated organic fraction with direct incineration of the mixed fraction (S-2), biomethanization of the source-separated organic fraction, sorting of the mixed fraction and incineration of the rejected fraction (S-3), biomethanization of the source-separated organic fraction, sorting of the mixed fraction and incineration of the rejected fraction following aerobic stabilization of the organic fraction (S-4) and biomethanization of the source-separated organic fraction, sorting of the mixed fraction and landfill of the rejected following aerobic stabilization of the organic fraction (S-5). The Consortium for Waste Management (COGERSA) provide data regarding on transport and collection of waste and consumption of energy, water, oil and reagents at each processes. The results obtained suggest that

Scenario S-3 has the least impact on the analysed damage categories while the scenarios including landfilling produces the greatest impact in all the categories analysed. Regarding involved processes in studied scenarios, the transport produces a significant impact in the environment, biomethanization contributes to reducing the impact in all the damage categories and incineration adversely affects the categories of Human Health and Climate Change, but helps to reduce damage in the Resources category.

Fernández-Nava, Y., J. del Río, J. Rodríguez-Iglesias, L. Castrillón, & E. Marañón (2014) Life cycle assessment of different municipal solid waste management options: a case study of Asturias (Spain), JOURNAL OF CLEANER PRODUCTION 81:178-189.

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TRANSPORT & INDUSTRY

Analysis of greenhouse gas emissions of freight transport sector in China

Abstract - Due to the increasing commercial activities in China, the rapid growth of energy consumption and greenhouse gas (GHG) emissions in the freight transport sector has alarmed the Chinese central government. However, there is a lack of standard measure for evaluating GHG emissions generated from freight transport operations. To improve this situation, Chinese policy makers need to evaluate GHG emissions for energy saving and pollution reduction. This background leads us to examine the GHG emission trajectories and features of Chinese freight transport patterns in the last decade, i.e. between 2000 and 2011. In this study, we examine different regions' freight turnover and energy consumption by various transport modes (i.e. railway, highway, waterway, aircraft, and oil pipeline) in China. Our results show that the total amount of GHG emissions caused by the Chinese freight transport sector reached 978 million tons in 2011, indicating an average annual growth of 74 million tons CO2e for the last decade. Shandong, Anhui, and Henan are the main provinces producing GHG emissions, representing 11.7%, 10.3%, and 10% of total emissions generated from the freight transport sector in China, respectively. This study also compares the regional GHG emissions from different freight transport modes including railway, highway, waterway, air transport, and oil pipeline. Based on the findings, policy implications are provided on how to mitigate freight transport emissions among different Chinese regions.

Tian, Y., Q. Zhu, K. Lai, & Y. H. V. Lun (2014) Analysis of greenhouse gas emissions of freight transport sector in China, JOURNAL OF TRANSPORT GEOGRAPHY 40:43-52.

Assessing greenhouse gas and related air pollutant emissions from road traffic counts: A case study for Mauritius

Abstract - The road transport sector is one of the major contributors of greenhouse gases and other air pollutants emissions. Regional emissions levels from road vehicles were investigated, in Mauritius, by applying a fuel-based approach. We estimated fuel consumption and air emissions based on traffic counts on the various types of classified roads at three different regional set ups, namely urban, semi urban and rural. The Relative Development Index (RDI), a composite index calculated from socio-economic and environmental indicators was used to classify regions. Our results show that the urban motorways were the most polluting due to heavy traffic. Some rural areas had important pollution levels as well. Our analysis of variance (ANOVA), however, showed little difference in emissions among road types and regions. The study can provide a simple tool for researchers in countries where data are very scarce, as is the case for many developing countries.

Sookun, A., R. Boojhawon, & S. D. D. V. Rughooputh (2014) Assessing greenhouse gas and related air pollutant emissions from road traffic counts: A case study for Mauritius, TRANSPORTATION RESEARCH PART D: TRANSPORT AND ENVIRONMENT 32:35-47.

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Fossil Fuels

Emissions of methane from offshore oil and gas platforms in Southeast Asia

Abstract - Methane is a substantial contributor to climate change. It also contributes to maintaining the background levels of tropospheric ozone. Among a variety of CH4 sources, current estimates suggest that CH4 emissions from oil and gas processes account for approximately 20% of worldwide anthropogenic emissions. Here, we report on observational evidence of CH4 emissions from offshore oil and gas platforms in Southeast Asia, detected by a highly time-resolved spectroscopic monitoring technique deployed onboard cargo ships of opportunity. We often encountered CH4 plumes originating from operational flaring/venting and fugitive emissions off the coast of the Malay Peninsula and Borneo. Using night-light imagery from satellites, we discovered more offshore platforms in this region than are accounted for in the emission inventory. Our results demonstrate that current knowledge regarding CH4 emissions from offshore platforms in Southeast Asia has considerable uncertainty and therefore, emission inventories used for modeling and assessment need to be re-examined.

Nara, H., H. Tanimoto, Y. Tohjima, H. Mukai, Y. Nojiri, & T. Machida (2014) Emissions of methane from offshore oil and gas platforms in Southeast Asia, Scientific Reports 4.

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Cross Cutting, Other SLCP Source Sectors & SLCP Vulnerable Regions

Ship track observations of a reduced shortwave aerosol indirect effect in mixed-phase clouds

Abstract - Aerosol influences on clouds are a major source of uncertainty to our understanding of forced climate change. Increased aerosol can enhance solar reflection from clouds countering greenhouse gas warming. Recently, this indirect effect has been extended from water droplet clouds to other types including mixed-phase clouds. Aerosol effects on mixed-phase clouds are important because of their fundamental role on sea ice loss and polar climate change, but very little is known about aerosol effects on these clouds. Here we provide the first analysis of the effects of aerosol emitted from ship stacks into mixed-phase clouds. Satellite observations of solar reflection in numerous ship tracks reveal that cloud albedo increases 5 times more in liquid clouds when polluted and persist 2 h longer than in mixed-phase clouds. These results suggest that seeding mixed-phase clouds via shipping aerosol is unlikely to provide any significant counterbalancing solar radiative cooling effects in warming polar regions.

Christensen, M. W., K. Suzuki, B. Zambri, & G. L. Stephens (2014) Ship track observations of a reduced shortwave aerosol indirect effect in mixed-phase clouds, Geophysical Research Letters 41(19):6,970-6,977.

Aircraft soot indirect effect on large-scale cirrus clouds: Is the indirect forcing by aircraft soot positive or negative?

Abstract - The indirect effect of aircraft soot on cirrus clouds is subject to large uncertainties due to uncertainty in the effectiveness of aircraft soot acting as heterogeneous ice nuclei (IN) and the complexity caused by background ice nucleation, which introduces two major competing ice nucleation mechanisms: homogeneous freezing that generally produces more abundant ice particles and heterogeneous nucleation that generally produces fewer ice particles. In this paper, we used the coupled Community Atmosphere Model version 5.2 (CAM5)/IMPACT model to estimate the climate impacts of aircraft soot acting as IN in large-scale cirrus clouds. We assume that only the aircraft soot particles that are preactivated in persistent contrail cirrus clouds are efficient IN. Further, we assume that these particles lose their ability to act as efficient IN when they become coated with three

monolayers of sulfate. We varied the background number concentration of sulfate aerosols allowed to act as homogeneous ice nucleation sites as well as the dust concentrations that act as heterogeneous ice nuclei to examine the sensitivity of the forcing by aircraft soot to the background atmosphere. The global average effect can range from a high negative (cooling) rate, 0.35 W m 2, for the high sulfate/low dust case to a positive (warming) rate, +0.09 W m 2, for the low sulfate/low dust case (default CAM5 setup) when approximately 0.6% of total aviation soot acts as IN. The net negative forcing is caused by the addition of IN to a background atmosphere that is dominated by homogeneous nucleation (mainly in the tropic Indian Ocean, Central America, and North Atlantic Ocean). The forcings can be all positive, about +0.11 to +0.21 W m 2, when the background atmosphere is dominated by pure heterogeneous ice nucleation.

Zhou, C., & J. E. Penner (2014) Aircraft soot indirect effect on large-scale cirrus clouds: Is the indirect forcing by aircraft soot positive or negative?, JOURNAL OF GEOPHYSICAL RESEARCH: ATMOSPHERES 119(19):11,303-11,320.

The twenty-first-century Arctic environment: accelerating change in the atmospheric, oceanic and terrestrial spheres

Abstract - The Arctic possesses distinctive environmental characteristics that act as strong, positive feedbacks on atmospheric warming; in fact, it is almost uniquely susceptible to rapid change brought about through climate warming from both natural and anthropogenic sources. The aim of this commentary is to outline recent and probable future environmental changes in the Arctic. It commences with a consideration of rates of change through the satellite era in air temperatures, sea ice extent, snow cover and the state of balance of the Greenland Ice Sheet. This is subsequently set against fluctuations over previous centuries and millennia. From this observational basis, the commentary moves on to consider factors which particularly amplify rates of change in high northern latitudes, before addressing further feedbacks which may become important, and how Arctic changes may proceed up to the year 2100.

Hodgkins R. (2014) The twenty-first-century Arctic environment: accelerating change in the atmospheric, oceanic and terrestrial spheres, THE GEOPHYSICAL JOURNAL 180(4):429-436.

Effects of decarbonising international shipping and aviation on climate mitigation and air pollution

Abstract - This paper assesses the effects of a global emissions trading scheme (GETS) for international aviation and shipping as a way of reducing emissions of both greenhouse gases (GHG) and other atmospheric emissions that lead to air pollution. A prior assessment of such integration requires the coupling of energy–environment–economy (E3) global modelling of mitigation policies with the atmospheric modelling of pollution sources, mixing and deposition. We report the methodology and results of coupling of the E3MG model and the global atmospheric model, p-TOMCAT. We assess the effects of GETS on the concentrations of atmospheric gases and on the radiative forcing, comparing a GETS scenario to a reference BASE scenario with higher use of fossil fuels. The paper assesses the outcome of GETS for atmospheric composition and radiative forcing for 2050. GETS on international shipping and aviation reduces their CO2 and non-CO2 emissions up to 65%. As a consequence atmospheric concentrations are modified and the radiative forcing due to international transport is reduced by different amounts as a function of the pollutant studied (15% for CO2, 35% for methane and up to 50% for ozone).

Dessens, O., A. Anger, T. Barker, & J. Pyle (2014) Effects of decarbonising international shipping and aviation on climate mitigation and air pollution, ENVIRONMENTAL SCIENCE & POLICY 44:1-10.