ACM 2017

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S3A Presentation

S3A-1

Highly Resolved Concentration Profiles of Ultrafine Particles in Urban Micro-environment: Effects of micro-built environments and micro-meteorology, and implications for pedestrian exposure

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Vehicle emissions are rapidly diluted away from roadways, leading to highly spatially-heterogeneous distributions of air pollutants in urban areas. A large fraction of the exposure of individuals to traffic-related pollutants can be attributed to relatively short periods of time spent on and near roadways, for which people are exposed to highly elevated pollutant concentrations compared to areas at even moderate distances from roadways. Recently, an increasing number of air quality studies have adopted a mobile platform to investigate heterogeneous air pollution characteristics in urban areas as well as to estimate vehicular emissions.
This presentation shows (1) the effects of micro-built environments and in-canopy turbulence on ultrafine particle concentration levels (UFP, <100 nm in diameter) in block scale; (2) the characteristics of highly resolved cross-intersection UFP profiles using 1,744 profiles covering 90 m before and after each intersection center; and (3) the variations in pedestrian exposure levels to UFP when bus-stops sit at different distances from the intersections. Data were obtained from six urban sites with distinct built environments for both morning and afternoon. Measurements were made within 1.5 m of the sidewalk and at breathing height (1.5m above ground level) to approximate sidewalk exposures. Block-scaled UFP levels were highly variable in different building configurations and concentration profiles were strongly influenced by high emission events from accelerating vehicles. Thus, people staying longer at the intersection of specific built- and traffic-environments have increasing chance to be exposed to short-term extremely high concentrations of UFP. The time-duration exposure calculations considering inhaled air volume, suggest moving a bus stop from 20 to 40 m after the intersection reduces transit-users' exposure levels to UFP proportionally to the elevation magnitude at the intersection.

S3A-2

Climate responses of anthropogenic aerosols assessed with a coupled-ocean general circulation model MIROC

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To analyze the climate response of anthropogenic aerosols simulations with prescribed sea surface temperature and a coupled-ocean general circulation model are executed changing the ratios (0, 0.1, 0.3, 0.5, 0.8, 1.5, 2, 5, 10 times) of emission fluxes relative to the present for anthropogenic black carbon (BC) and sulfur dioxide (SO2). Although the radiative forcing of the aerosol-radiation interaction both at the tropopause and surface has linear trends with the changes in BC and SO2 emissions, the equilibrium experiments with the coupled-ocean model show no clear correlations of the change in BC emission with the change in the surface air temperature within the realistic emission (ratios between 0 and 2). The simulated results suggest that the change in the surface air temperature much depends on a change in the amount of water vapor, which implies that the variation of vertical profile of heating rate affected by the aerosol-radiation interaction is significant.

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S3A-3

Dampening effects of air pollution on land carbon uptake in China

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Atmospheric pollutants have both beneficial and detrimental effects on carbon uptake by land ecosystems. Surface ozone (O3) damages leaf photosynthesis by oxidizing plant cells, while aerosols promote carbon uptake by increasing diffuse radiation and exert additional influences through concomitant perturbations to meteorology and hydrology. China is currently the world's largest emitter of both carbon dioxide and short-lived air pollutants. The land ecosystems of China are estimated to provide a carbon sink, but it remains unclear whether air pollution acts to inhibit or promote carbon uptake. Here, we employ Earth system modeling and multiple measurement datasets to assess the separate and combined effects of anthropogenic O3 and aerosol pollution on net primary productivity (NPP) in China. In the present day, O3 reduces annual NPP by 0.6 Pg C (14%) with a range from 0.4 Pg C (low O3 sensitivity) to 0.8 Pg C (high O3 sensitivity). In contrast, aerosol direct effects increase NPP by 0.2 Pg C (5%) through the combination of diffuse radiation fertilization, reduced canopy temperatures, and reduced evaporation leading to higher soil moisture. Consequently, the net effects of O3 and aerosols decrease NPP by 0.4 Pg C (9%) with a range from 0.2 Pg C (low O3 sensitivity) to 0.6 Pg C (high O3 sensitivity). However, precipitation inhibition from combined aerosol direct and indirect effects reduces annual NPP by 0.2 Pg C (4%), leading to a net air pollution suppression of 0.8 Pg C (16%) with a range from 0.6 Pg C (low O3 sensitivity) to 1.0 Pg C (high O3 sensitivity). Our results reveal strong dampening effects of air pollution on the land carbon uptake in China today. Following the current legislation emission scenario, this suppression will be further increased by the year 2030, mainly due to a continuing increase in surface O3. However, the maximum technically feasible reduction scenario could drastically relieve the current level of NPP damage by 70% in 2030, offering protection of this critical ecosystem service and the mitigation of long-term global warming.

S3A-4

Development of statistical forecasting model for hourly PM2.5 using Distance Correlation Coefficients and Support Vector Regression

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WITHDRAW

A challenge in air quality study is to accurately predict the temporal and spatial changes of ambient air compositions. In this study, we developed a statistical forecasting model DC-SVR with integrating distance correlation coefficients (DC) reducing predictor dimensionality and support vector regression (SVR) predicting hourly PM2.5 concentrations in Yangtze River Delta of East China. Based on the hourly data of PM2.5 concentrations observed in Hangzhou and Nanjing, two central cities of East China and the high temporal and spatial resolution meteorological data simulated with the Weather Research and Forecast (WRF), the dominant predictors were identified from the nonlinear relationship between hourly PM2.5 concentrations and a set of predictors including meteorological elements(temperature, specific humidity, wind speed, pressure, planetary boundary layer height and precipitation) on and before 24 hours, by employing the DC method which is flexible in that it can describe arbitrary regression relationship between two variables without model assumption and parameter conditions. With introducing the DC-identified predictors into the SVR, a statistical forecasting model DC-SVR for hourly PM2.5 was developed. The SVR is appealing algorithms for its great nonlinear generalization ability, relatively small number of training data and robustness.

The test of statistical forecasting model DC-SVR in January, April, July and October 2015 presents that the hourly PM2.5 forecasting accuracy averaged over 4 months reached up to 72.41% and 70.13% respectively in Hangzhou and Nanjing, proving that DC-SVR is a robust and powerful software for hourly PM2.5 prediction in Hangzhou and Nanjing. A comparison with results obtained using SVR was also carried out. It followed that the MB, MAE and RMSE produced by DC-SVR model were smaller than SVR, and correlation coefficient and accuracy produced by DC-SVR model were higher than SVR. Thus, the DC-SVR model obtains more accurate forecasting results and applications of DC have positive effect via size reduction of the set of predictors. In general, the statistical model DC-SVR could be used in the operational air quality forecast with higher prediction ability.

The statistical model DC-SVR comprises the following steps:

Step one: establish the set of predictors.

By considering dynamic effect of the previous meteorological elements, we defined a set of predictors which consists of meteorological elements including temperature, specific humidity, horizontal wind speed, sea level pressure, planetary boundary layer height and precipitation on and before 24 hours, and dimensionality of the set of predictors is 150.

Step two: Selection of important predictors.

The databases are monthly divided into training set and testing set. The high dimensionality of predictors could lead to information redundancy. We use DC in the training set to reduce the dimensionality of the set of predictors and incorporate the important predictors into SVR model. Optimal size of important predictors is determined by k-fold cross validation, and we set k to 6.

Step three: forecast model.

SVR is monthly applied to predicted hourly PM2.5 concentrations within 168 hours in Hangzhou and Nanjing, after selecting important predictors.

S3A-5

Estimating the effects of the transboundary transport and local emissions of atmospheric pollutants in South Korea

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The air quality of South Korea, located in the east of China, is affected by persistent westerlies, showing the relationship to the emission in upwind region. High aerosol concentration in South Korea is also attributed to local emissions. Particularly, the industrial complex and power plants are concentrated in the Chungcheongnam-do (CN), located by the southwest part of Seoul Metropolitan Area (SMA). In this study, we evaluate the contribution of both the transboundary transport of Chinese pollutants and local emissions in the CN to the air quality in South Korea during Korea-US Air Quality (KORUS-AQ) campaign, 1 May to 12 June in 2016. The KORUS-AQ campaign aims to investigate characteristics of air quality and enhance the performance of the air quality model prediction and satellite retrieval.

Based on the information of aerosol optical depth (AOD) obtained from ground-based Aerosol Robotic NETwork (AERONET) sunphotometer and surface in-situ Particulate Matter (PM) measurements at 19 stations, high and low aerosol pollution cases are classified first. Then, 3-day back-trajectories are calculated using National Ocean and Atmospheric Administration (NOAA) HYbrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model at each AERONET and PM measurement site to investigate whether transport pattern is different in accordance with the classified cases about aerosol amounts.

As a result, we find the distinct pathway of air-mass transport from eastern China; When high AOD is observed at station located in the western coast of South Korea, air masses are directly transported from Shandong peninsular to the Korean peninsula. In contrast, air masses are mostly transported from northwestern or northern China during the period of low AOD conditions. When PM2.5 (particulate matter with diameter less than 2.5 micron) detected at SMA sites is greater than Korean government criteria (50 micrograms per cubic meter for 24-hour average PM2.5), SMA sites are mostly affected by air mass flows through the CN area. These results indicate that transport pattern can be different vertically and surface aerosol concentration has different transport pattern from the transport pattern related to the variation of total column aerosol.

To further investigate the aerosol transport pattern into the Korean peninsula, we use AOD from satellite-borne Geostationary Ocean Color Imager (GOCI). Correlation analysis is performed using GOCI AOD to find the main source region of transported aerosol for each surface station. The result shows the remote connection of aerosol concentrations between South Korea and China. Particularly, we find the distinct transboundary transport pattern from Shandong peninsular to western coastal sites in Korea.

We finally try to confirm our findings based on several high polluted cases during KORUS-AQ campaign. The case in 25-26 May is the representative pattern of

large aerosol transport from China during the campaign. Both GOCI AOD images and back-trajectories in this case show that air masses are transported from Shandong peninsular to South Korea. As air masses are transported to South Korea through the Yellow Sea, AOD and PM observed in Korean peninsula increase together. However, the other transport case in 30-31 May presents slightly different vertical distribution of aerosol amount. This case also shows movement of air masses across the Yellow Sea from western China. But surface PM measurement has little increment or no change in this case different from an increase of AOD. These cases reveal that the vertical properties of aerosol amount are another important information to figure out the transport pattern. All these findings in this study indicate that the reduction of local emissions as well as Chinese pollution will result in the mitigation of aerosol pollution problems in South Korea.

S3A-6

Source attribution of PM2.5 for Korea during the KORUS-AQ campaign using GEOS-Chem adjoint model

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An intercontinental cooperative air quality field study in Korea, KORUS-AQ was held in 2016, where extensive observations of PM2.5 concentrations and its precursors were conducted. In this study, we investigated source contributions to PM2.5 in Korea under various meteorological conditions during the KORUS-AQ campaign using the GEOS-Chem 3-D global chemical transport model and its adjoint. First, we updated the model with the latest regional emission inventory, NIER-KU/CREATE, with diurnally varying NH3 emissions, and with photolysis of particulate nitrate. The updated model was evaluated by comparing against observed daily PM2.5 concentrations and chemical components comprising PM2.5 at 6 ground sites (Bangnyung, Olympic, Bulkwang, Gwangju, Ulsan, Jeju) and vertical profile observations from the NASA DC-8 aircraft during the campaign. The updated features improved the simulation of nitrate, which had been overestimated in the region during the period. Next, we conducted adjoint sensitivity analysis for surface PM2.5 at 6 ground sites over Korea with respect to emissions from each species/sector/grid sell in the model. We calculated relative contributions of emission sources to PM2.5 over Korea under various meteorological conditions.

S3A-7

Detection of wildfire in Korea using machine learning and Himawari-8 satellite data

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Wildfires damage terrestrial ecosystems and release greenhouse gases and aerosols into the atmosphere. Wildfires are unpredictable events, making it difficult to access them. Thus, monitoring wildfires using satellite remote sensing data has been widely conducted. In order to detect wildfires, various satellite data such as Moderate-resolution imaging spectroradiometer, (MODIS), Visible infrared imaging radiometer suite (VIIRS), Landsat series, and geostationary operational environmental satellite (GOES) have been used. In particular, MODIS and VIIRS provide wildfire products (i.e., fire mask). While these wildfire detection algorithms work well in certain areas where they were calibrated and validated, they don't work well especially for East Asia, resulting in a significant amount of false alarms. In addition, the existing algorithms do not detect small wildfires, which are very common in South Korea. Wildfire detection studies in Korea have used MODIS and Communication, Ocean and Meteorological Satellite (COMS) Meteorological Imager (MI). Since data from Himawari-8 Advanced Himawari Imager (AHI), a Japanese geostationary satellite sensor, have been recently available with enhanced specifications (i.e., improved spatial, spectral, and temporal resolutions), there are efforts to improve wildfire detection algorithms using Himawari data.

The purpose of this study was to develop a novel algorithm to detect wildfires using Himawari-8 satellite data in South Korea. Random forest (RF) machine learning was adopted to develop the algorithm. Himawari-8, launched in October 2014 and started to provide operational data in July 2015, is the geostationary satellite operated by the Japan Meteorological Agency (JMA). Himawari-8 collects data every 10 minutes at 16 bands from visible to infrared at a 500 m - 2 km resolution covering from China to Australia. In-situ wildfire data provided by the Korea Forest Service were used as reference data. First, we selected input parameters contributing to wildfire detection among each band reflectance, radiance, brightness temperature (BT), band ratios, and BT differences using variable importance identified by RF. As Himawari-8 does not provide a cloud mask product yet, we removed cloud pixels using our own cloud masking algorithm designed based on the existing cloud masking algorithms for other similar satellite sensor systems. Once cloud masking is conducted, the selected input parameters are used in RF again to finally detect wildfires. Post processing based on thresholding approaches to further reduce false alarm is conducted. Since time series data with a 10 min interval were used, lead time on how early the algorithm detect fires was examined. Results showed that the proposed algorithm detected wildfires better than the existing ones, especially small-scale wildfires. In addition, false alarm rates were found in the existing algorithms, but the rate was greatly reduced when using the proposed approach.

S3A-8

Observation-based estimates of the mass absorption cross-section of the black and brown carbon aerosols during GoPoEx 2014

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Black carbon (BC) is well known as a major contributor to the atmospheric heating by absorbing the solar radiation reaching the Earth's surface. However, recent studies have suggested that the effect of brown carbon (BrC) on the light absorption should be also considered in most chemical transport and climate models because the solar absorption of BrC is not negligible and even comparable to that of BC at visible to UV wavelengths. Most modeling researches use mass absorption cross-section (MAC), which is a wavelength-dependent parameter characterizing the optical properties of aerosols, to calculate light absorption properties of BC or BrC. Although many studies based on the observation show that the MAC has a large spatial and temporal variability, most modeling studies have used a specific value of BC MAC, usually 7.5 m2 g-1 at 550 nm. In addition, the MAC of BrC is seldom considered in most chemical transport and climate models. Here, therefore, the MAC of BC and BrC are separately determined from co-located simultaneous in-situ measurements, such as Continuous Soot Monitoring System (COSMOS), Continuous Light Absorption Photometer (CLAP) and Sunset EC/OC analyzer, at Gosan climate observatory, Korea during Gosan Pollution Experiment in January 2014 (GoPoEx 2014). Furthermore, the contribution of BC and BrC on aerosol light absorption are estimated by applying the new MAC of BC and BrC obtained in this study. The value of BC MAC is estimated to be about 6.4±1.5 m^2 g^{-1} at 565 nm from COSMOS and Sunset EC/OC analyzer measurements during GoPoEx 2014. It has reported to be ranged from 10 to18 m^2 g^{-1} in America or Europe (Sharma et al., JGR, 2002; Watson and Chow, JGR, 2002; Lack et al., PNAS, 2012), but the values in China have observed ranged to be 4-7 m^2 g^{-1} (Shen et al., AE, 2013; Cui et al., STE, 2016). Aerosol absorption coefficient (AAC) and BC mass concentration from COSMOS, meanwhile, are approximately 15-20% lower than those from CLAP. This difference represents the effect of BrC on light-absorbing properties. The absorption coefficients of BrC is determined by the difference of absorption coefficients from CLAP and COSMOS measurements to derive the value of BrC MAC following three methods. First, the BrC absorption coefficient is divided by the difference of mass concentration from Aethalometer and COSMOS measurements. Second, the mass concentration of water-soluble organic carbon and inferred light-absorbing property of water-insoluble organic carbon are used. Third method, suggested by Chung et al. (ACP, 2012), assumes that the BrC mass concentration is regarded as the mass concentration of organic carbon. The values of BrC MAC obtained from the three methods ranged from 1.0 m^2 g^{-1} to 1.5 m^2 g^{-1} at 565 nm which is slightly higher than those from previous studies (Du et al., AE, 2014; Yan et al., AE, 2015; Srinivas et al., AE, 2016). From the values of BC and BrC MAC, the contribution of BC and BrC to AAC is estimated to be about 85-90%, and 10-15% of total AAC, respectively. For the variation of the contribution of BrC, it increases about 1% when the value of BrC MAC increases 10%.