ACM 2017

ASIAN CONFERENCE ON METEOROLOGY 2017 (ACM2017)

Poster Presentation

Session 3 [P-116~P-143]

P-116

Mapping nighttime PM2.5 from VIIRS DNB in Beijing using a linear mixed-effects model

Disong Fu (Institute of Atmospheric Physics, Chinese Academy of Sciences)
Xiangao Xia (Institute of Atmospheric Physics, Chinese Academy of Sciences)

Epidemiological studies investigating effects of PM2.5 concentrations on human health within urban areas requires surface PM2.5 concentrations at high temporal and spatial resolutions. Meanwhile, PM2.5 concentrations have a distinct diurnal variation. We found that the correlation of nighttime hourly PM2.5 concentrations and daily PM2.5 was lower (R_min=0.75) than that of daytime hourly PM2.5 and daily PM2.5 concentrations (R_min=0.87 between 6:00 AM and 18:00 PM). We developed a mixed effects model to derive nighttime estimations of surface PM2.5 in Beijing, using the Day/Night Band (DNB) of the Visible Infrared Imaging Radiometer Suite (VIIRS). The mixed effects model accounts for daily variations of AOD-PM2.5 relationships and shows good performance in model predictions (R2 of 0.85) and cross-validations (R2 of 0.53-0.98). Satellite-derived mean PM2.5 for Beijing was 85.3 μ g/m^3, 69.8 μ g/m^3, 92.5 μ g/m^3 and 125.7 μ g/m^3 over the study period (December 2013 to November 2014) for spring, summer, autumn and winter, respectively. We also demonstrate that mixed effects model in main urban area has better model predictions (R2 of 0.92). Predicted high-resolution daily PM2.5 maps are useful to identify pollution “hot spots” and estimate short- and long-term exposure.

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Long-term air quality monitoring and assessment in Ulaanbaatar city

Doljinsuren Myagmar (Hankuk University of Foreign Studies)
Gang Woong Lee (Hankuk University of Foreign Studies)

Air quality and the implications for human health have become a major concern in the Mongolian capital Ulaanbaatar. Approximately 45 percent of the total population in Mongolian lives in the Ulaanbaatar metropolitan area. A more thorough understanding of diurnal, monthly and longer-term patterns in air quality and their relationships with meteorological and social factors is urgently needed to improve the effectiveness of air quality controlling measures. Some recent studies have identified specific air pollutants as a major concern and examined their connection to ambient weather, and effects on human health and mortality in Ulaanbaatar.

This study used hourly data from five air quality monitoring stations operated by the National Agency of Meteorology and Environmental Monitoring of Mongolia (NAMEM) from 2009 to 2016. We selected stations representing different areas of the Ulaanbaatar region such as residential (ger is the Mongolian term for the traditional housing), industrial, roadside, modern residential, and remote areas for this study.

The annual average concentration of PM10 was extremely high (80 to 324 μg/m3) among the five sites, showing that the PM10 concentrations in Ulaanbaatar have exceeded WHO air quality standards by 4 to 16 times. Although monthly average PM10 concentrations at all five stations were highly variable, PM10 concentrations in cold months (Nov-Feb) were significantly higher than those in other months, while lower concentrations were found in warmer months (Jun-Aug). The highest monthly averages PM10 concentrations were found in the ger area (913μg/m3) and the remote area (146μg/m3) in January. The lowest monthly average PM10 concentrations were measured in the remote area (41μg/m3) and the roadside area (92 41μg/m3) in June. PM10 concentrations worsened in the winter, reflecting the demand for indoor heating. This study also found diurnal changes in PM10 concentrations, with higher concentrations in the morning and night, about 1 to 3 hours later than the presumed intensive coal consumption periods for cooking and heating. The highest PM10 were measured between 10 am and 12 pm and between 9 pm and 12 am.

Overall, our study has collected evidence that PM10 concentration in the Ulaanbaatar metropolitan region is becoming more serious as urbanization and energy use increases. The metropolitan region has a very high population density in ger areas, and air pollution has likely impacted human health. In depth analysis of air quality with socio-econo and meteorological variations will be presented at the conference. The results of this study provide a sound basis for future studies of air quality and linkages to socioeconomic and meteorological factors.

Key words: Ulaanbaatar, Mongolia, particulate matter, ger residential area

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Recent hot summers weaken the decreasing tendency of fine particulate matter (PM2.5) in Seoul, Korea

Greem Lee (Seoul National University)
Chang-Hoi Ho (Seoul National University)
Hye-Ryun Oh (Seoul National University)

To reduce adverse impacts of particulate matters (PMs) on human health, ecosystems, and socio-economic systems, the Ministry of Environment of South Korea has established National Environmental Comprehensive Plans and implemented nationwide clean-up activities since early 2000s. Thanks to the air pollution reduction policies, both fine (PM2.5) and coarse (PM10-2.5) particulate matters significantly decreased in all seasons for the period 2002-2015 in Seoul. This study examines the difference in the long-term decreasing trends of PM2.5 and PM10-2.5 and possible causes of this discrepancy. Data of mass concentrations of PMs and atmospheric variables (surface air temperature, surface solar radiation, precipitation, and relative humidity) were provided from the Seoul Metropolitan Government Research Institute of Public Health and Environment and the Korea Meteorological Administration, respectively.

PM2.5 has a slower decreasing tendency than PM10-2.5 for summer, and that this discrepancy is likely due to the large increases of summer surface air temperature (0.13°C year-1). The difference in the decreasing trends of two PMs is dominant in the daytime, during which hourly surface air temperature and its increasing rate are the highest in a given year. Considering that secondary formations of PM2.5 generally accelerate as temperature increases, this study suggests that the slower decrease of PM2.5 than that of PM10-2.5 is attributable to secondary formations of PM2.5. Moreover, the discrepancy in the trends of two PMs induces recent high ratio of PM2.5 to PM10-2.5 concentrations and the increase in the number of days with a high PM2.5 proportion. In general, a higher proportion of PM2.5 than that of PM10-2.5 indicates the large anthropogenic emissions. According to our results, however, even when concentrations of PM2.5 and PM10-2.5 decrease as a result of the implementation of air pollution reduction policies, PM2.5 can decrease more gradually than PM10-2.5 due to the changes of atmospheric conditions; therefore, the proportion of PM2.5 can be higher than that of PM10-2.5. During autumn, winter, and spring, however, the differences between the decreasing rates of concentrations of PM2.5 and PM10-2.5 are insignificant, and the change in surface air temperature is negligible. Other key factors that affects formation and dispersion of PM2.5, such as insolation, precipitation, and relative humidity, does not show meaningful changes over the analysis period.

PM2.5 is formed not only from the anthropogenic emissions but also from secondary formations, and various meteorological factors can influence the mechanisms of formations by season. Among several factors, surface air temperature in urban area is increasing for decades, partially by anthropogenic climate change. The results emphasize the necessity of monitoring long-term concentrations of PM2.5 and PM10-2.5 and continuous in-depth study on the relationship between PMs and atmospheric conditions. The findings in this study will be useful for the independent and separate establishment of reduction policies for PM2.5 and PM10-2.5 to prepare for global warming.

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Source Apportionment of ambient pollutants using EPA Positive Matrix Factorization (PMF) 5

Dhurgham Radhi Obaid (Hankuk University of Foreign Studies)

The air pollutantsincluding aerosol and gaseous species interact both directly and indirectly with earth radiation budget, causing a reduction in visibility and deterioration of human health. Due to the complex chemistry involved in the combustion of fossil fuels under meteorological conditions, a large number of trace gas species are emitted. Fine particles contain between 20-90% of organic matter by mass, and a major component of this fraction includes water-soluble organic carbon (WSOC), which are involved in the liquid-phase. The scientific goal of this study is to predict pollutant sources and make source apportionments for ambient particulatematter in Baengnyeong Island and Yongin, South Korea, by applying Positive Matrix Factorization (PMF).

United States Environmental Protection Agency (U.S. EPA) PMF model was applied to asourceof apportionment of the study based on online datasets in order to identify the different emission sources including vehicles emission, coal combustion, biomass burning and the long-range transport of air pollution. The real-time measurements were conducted for WSOC and ionic components (NO_3^-, SO_4^{2-}, NH_4^+, Na+ Mg^{2+}, Ca^{2+}.. etc.) in PM2.5 using the particles into liquid sampler (PILS) coupled with Total Organic Carbon (TOC) analyzer and Ion Chromatography (IC). PM2.5 precursor gases for PM2.5 including O_3, NOx (NO and NO_2), SO_2 and NH_3 were measured in real time.

Three factors pollutants were found during summer (May-June) in Baengnyeong Island. Secondary sources (NO_3^-, SO_4^{2-}, NH_4^+, K^+) showed high concentrations (91-96%). Mobile source with ahigh concentration of CO, O_3, and BC with percentage 63.8%, 51.8%, and 50%, respectively, were identified. Source of crustal compoundswasanalyzed with ahigh concentration of metals (Pb, Ca, Ni, Mn, As, Fe, Zn,Ti,K) with percentage variation (70-92%). Furthermore, source apportionment in HUFS -Yong-in, South Korea during Winter 2016 and Summer 2017 will provide the identification of emission sources, physicochemical characteristics of PM2.5, PM10 and the relationship between PM2.5 and its precursor gaseous species.

Key words: Positive Matrix Factorization (PMF), Source apportionment

Acknowledgment: Supported by KOICA (Korea International Cooperation Agency) / KMA (Korea Meteorological Administration)

P-120

Chemical characteristics of PM2.5 and gaseous precursor species during spring 2017 downwind of Seoul

Kamelya Mukasovna Zhangireyeva (Hankuk University of Foreign Studies)

With rapid industrialization and urbanization, air pollution has become the main environmental issue, focusing with the fine particulate matter less than 2.5 μm in diameter (PM2.5) being the main concern due to its adverse effect on human health, visibility degradation, and the climate change. Though primary sources of PM2.5 are well-known, our understanding of secondary pollutants and the reactions they undergo is more limited.

The production of sulfate (SO_4^{2-}), nitrate (NO_3^-) and ammonium (NH_4^+) and contributions to PM2.5 depend on the concentrations of the precursors (SO_2, NOx ($NO+NO_2$), NH_3), the characteristics of pre-existing aerosols, and meteorological conditions. This study aimed to investigate the relationships among precursor compounds, identify changes in gas-particle concentrations and understand the impact of meteorological conditions on PM2.5 formation. Intensive measurements of PM2.5 and precursor gas were conducted from April to May, 2017 at the downwind location of Seoul - Hankuk University of Foreign Studies, Global campus, Natural Science building (127°,15'58.0E 37°20'18.5°N).

The PM2.5 ionic species Na^+, NH_4^+, K^+, Ca^{2+}, Mg^{2+}, NO_2^-, NO_3^-, SO_4^{2-} and Water-Soluble Organic Carbon (WSOC) and gas species O_3, SO_2, NO, NO_2, NH_3 were measured. Semi-continuous real time measurements of PM2.5 ion composition were made using a Particle-into-Liquid Sampler (PILS) system coupled to ion chromatographs (IC) and total organic carbon detector (TOC) with time resolution 30 minutes. Chemilumiescence Detector (CLD), Thermo Environmental instrument, was used for measuring NO, NO_2, O_3, NH_3 gas species. SO_2 and NO_2 gas species were measured using Cavity Attenuated Phase Shift (CAPS), Teledyne advanced pollution instrumentation, with time resolution 1 minute. To provide insight into relationships between ionic and gaseous components and the influence of environmental conditions on PM2.5, meteorological data were also used in this study.

The results show the expected diurnal variations in ionic and gaseous precursor species, the partitioning ratio of their phase conversions between gas and aerosol (gas/ionic ratios of ammonia/ammonium, NOx/nitrate and sulfur dioxide/sulfate) and identification the transport of air masses from regions with higher emissions to the sampling site. This study will be particularly useful to further identify sources of aerosols at the study site and delineate the contribution from natural and anthropogenic sources.

Acknowledgment: Supported by KOICA (Korea International Cooperation Agency)/ KMA (Korea Meteorological Administration)

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Review on Methane Gas Emission from Wastewater Treatment Facilities

Muluken Kere Ewnetu (Hankuk University of Foreign Studies)
Hea Jho Eun (Hankuk University of Foreign Studies)

Anthropogenic emission of gases, over the past couple of hundred years, have led to a considerable increase of greenhouse gases in the atmosphere. The atmospheric concentration of greenhouse gases, namely, CO_2, CH_4, and N_2O have increased approximately by 15, 150, and 15%, respectively, since 1800. CH_4 is an important and potent greenhouse gas with a Global Warming Potential (GWP) 28 times higher than CO_2 estimated on the bases of an equivalent mass over 100 year time scale. There are sizeable research works done regarding the CH_4 produced from natural and anthropogenic sources where wastewater management systems are also considered among the potential sources that could emit CH_4 gas as a byproduct of a wastewater management process. However, a whole lot left of work is to be done to bring the international community to consensus. This review was conducted in light of summarizing the research works done so far to estimate the CH_4 emission from wastewater management systems, giving special emphasis to the wastewater management practices underway in developing nations. An extensive literature review was carried out to summarize the current understanding of the magnitude and rates of CH_4 emission from wastewater management facilities. It is found from the studies reviewed that wastewater treatment processes can indeed be a potential source for CH_4 emission and CH_4 is emitted dominantly from distinct wastewater management system components and treatment plant compartments, namely sewer lines (both pressurized and unpressurised) and primary and secondary sludge treatment compartments where anaerobic digestion of organic load take place. Anaerobic fermentation of primary and secondary sludge could be a source for more than 75% of the total CH_4 produced from wastewater management facilities. Studies conducted on a gravity sewer line and rising main showed emission factor ranging from 4.5 mg-1 L-1 to 10.5 of CH_4 mg-1 L-1 (Liu et al. 2015, Chaosakul, Koottatep & Polprasert 2014). Other research has shown that the emission factor of CH_4 gas is much higher than N_2O for activated sludge process and anoxic/anaerobic/oxic (A_2O) process. The emission factor for CH_4 vary depending on the type of wastewater management systems used to treat the wastewater and the section of wastewater treatment plant within the system. The emission factor only from wastewater treatment plant was reported within the range of 0.2g - 11.g Kg-1 COD-1 influent (Hwang, Bang & Zoh 2016, Czepiel, Crill & Harriss 1993, Daelman et al. 2012). According to (Daelman et al. 2012), the emission factor calculated from measured values of a waste water treatment plant found to be greater than 8.5g Kg-1 COD-1 influent (28%), the emission factor obtained by using the estimation method recommended by International Panel of Climate Change(IPCC). This can be a manifestation for the limitation of using a fixed emission factor to estimate an emission. In addition, using an emission factor computed based on a field test carried out some 20 years ago can be a sources of error in estimating emissions.

Key words: Greenhouse gases, CH4 emission, Wastewater treatment.

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Characterization of the atmospheric precursor gases for PM2.5 aerosols in Yong-in, Korea

Modeste Mugabo (Hankuk University of Foreign Studies)
Eun Hea Jho (Hankuk University of Foreign Studies)

The recent researches have shown that atmospheric photochemical reactions between both primary and secondary chemical species result in the formation of new aerosols in the atmosphere. According to their aerodynamic diameter in micrometer [μ m], the atmospheric small particles are classified as, PM25, PM10, and PM2.5. World Health Organization (WHO) reported that PM2.5 was found to have more health effects as well as environmental effects. The smallest particles (PM2.5) were found to have more health effects as they affect the respiratory system causing lung diseases including lung and blood cancer, asthma and bronchitis. The scientific goal of this study is to understand the formation of PM2.5 aerosols from their precursor gases.

From January 2017, to May 2017, the semi-continuous field measurements of Ozone (O3), Nitrogen Oxides (NOx= NO + NO2), sulfur dioxide (SO2) and ammonia (NH3) PM2.5 precursor gases was conducted. The measurements site was located in Hankuk University of Foreign Studies (HUFS), Yong-in, Korea. The real time concentrations of O3, SO2, NOx, and NH3 have been analyzed by gas analyzer instruments using Chemi-Luminescence Detection (CLD) method, whereas Cavity Attenuated Phase Shift (CAPS) method has been used to analyze the real time concentration of SO2. The statistical analysis has been applied to check the relationship between gas species, whereas the gas to particle partitioning has been used to check out the potential of precursor gases to be converted into new PM2.5.

The highest diurnal concentration of NO, NO2, SO2, O3 and NH3 was 22 ppbv at 9:00 A.M., 30 ppbv at 11:00 A.M, 4 ppbv at 3:00 P.M, 27 ppbv at 4:00 P.M and 6 ppbv at 8:00 P.M respectively. The formation rate of new PM2.5 by photochemical reaction was found to depend on the temperature, RH, and mass concentration of PM2.5 precursor gas species. The NO2 and SO2 gas to particle partitioning showed that the most of the available sulfur and nitrogen remains in the gas phase, representing potential for formation of additional NO3 and SO4 particulates. The presence of NH3 and SO2 in the gas phase also contributed to the formation of ammonium sulfates (NH4)2(SO4) in high humidity condition. With the current preliminary results it was concluded that the formation of new PM2.5 from their precursor gas species has a significant additional contribution to the local and long range transportation pollutants in Yong-in, Korea.

Key words: PM2.5, Particulate Matter with aerodynamic diameter less than 2.5 micrometer [μm]

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Characteristics of PM2.5 aerosols using PILS a Particle-into-liquid sampler of ambient air in Yong-in

Basma Msabah Louahem (Hankuk University of Foreign Studies)
Eun Hea Jho (Hankuk University of Foreign Studies)

Aerosol has an important effect on many atmospheric and environmental processes. Aerosol species interact both directly and indirectly with Earth's radiation budget and effects reductions in visibility and human health, experimental sampling was designed and conducted to investigate semi-continuous measurement of PM2.5 concentrations and chemical composition at yong-in located at latitude: 37° 13' 60.00" N and longitude: 127° 11' 60.00" E.

The chemical composition of aerosol particles measured using PILS-TOC-IC at high time resolution combined with metrological data provide insight into real time changes in ionic composition and concentration of WSOC. In this study, we coupled a Particle-into-liquid sampler (PILS) to a total organic carbon analyzer (TOC) to enable high time-resolution measurements of water soluble organic carbon (WSOC), the same instrument was coupled to an ion chromatograph to measure changes in concentrations of water-soluble ions. The PILS-TOC-IC set-up is allows us to look at rapid changes in the concentration and composition of aerosols. Another aim of this study is to identify likely sources of the water soluble fraction of atmospheric aerosol during the study period.

The scientific goal of this study was understanding the physico-chemical properties of PM2.5 changes and sources of ambient aerosol particles in Yong-in, by studying a wide variety of fast changing properties, water-solubility and sources of ambient aerosols particles in ambient air as well as the diurnal changes of the chemical composition measured with a good time resolution combined with meteorological data, to assess the variability of sources and ambient levels. The preliminary results show significantly higher PM2.5 concentrations and variations during the nighttime than the daytime. These likely results from air masses transported from precursor So far, our measurements Show diurnal variations in WSOC between day and night time. This is likely due to stronger solar irradiation and higher temperatures that enhanced photochemical formation of secondary aerosol particles.

Identifying emission sources and additional physico-chemical characteristics of PM2.5 will provide a better understanding of PM2.5 aerosols in this region. We will also quantify the relationships between aerosol characteristics and metrological factors such as solar insolation, wind speed and wind direction.

Acknowledgment: Supported by (KOICA) Korea International Cooperation Agency and KMA (Korea Meteorological Administration)

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Characteristics of the Interannual Variation of Aerosol Optical Depth over East Asia in Boreal Spring

Seunghee Lee (Ulsan National Institute of Science and Technology)
Myong-In Lee (Ulsan National Institute of Science and Technology)
Kyu-Myong Kim (NASA Goddard Space Flight Center)

Aerosols have profound impacts on regional weather and climate variability. Mostly due to insufficient observations in spatial and the lack of long-term historical data, however, researches on investigating their sources, transport, and their linked mechanisms with large-scale weather and climate variability have been limited. It is relatively recent that more than a decade of AOD observations from the MODIS satellites have become available since 2000 and have been extensively used to study the characteristics of the interannual variation of aerosols in global to regional scales.

Aerosols consist of various species. Each species has different emission sources, thereby resulting in quite distinctive spatial pattern and time variation such as their dominant transport paths and seasonality. For example, Asian dust originated from Gobi and Taklamakan deserts has been recognized as a primary source of aerosols in East Asia spring. With in-situ and satellite data, many previous studies researched on the relationship between dust activity and large-scale climate variability in interannual timescale. Recently, contributions by combustion aerosols such as organic carbon, sulfate, and black carbon in East Asia are gaining more attention, despite the researches on those species are still suffered from a lack of direct observations and the uncertainty in their emission estimates. The amount of the sum of those aerosol components is indeed comparable with that of natural dust in the region, and Bond et al. (2004) attributed them to the biomass burning as a primary origin.

In this study, interannual variation of aerosol optical depth (AOD) in East Asia has been investigated using the Moderate Resolution Imaging Spectroradiometer (MODIS) data and the Modern Era Retrospective analysis for Research and Applications Version 2 (MERRA-2) for 2003-2015. MERRA-2 help understand the emission source and long-range transport mechanisms of aerosols in different species such as dust (DU), organic carbon (OC), black carbon (BC), sulfate (SU), and sea salt (SS). The data analysis focuses on boreal spring when the Siberian biomass burning is seasonally maximum. It is found that the significant increase of organic and black carbon is primarily attributed to the biomass burning emission in East Asia, which leads to a significant year-to-year variation of aerosol loading and pan-Pacific transport. An underlying physical mechanism is suggested that the anomalous large-scale climate variability associated with East Asia Jet Stream (EAJS) provide favorable conditions to increase the AOD of organic and black carbon in Northeast Asia. We suggest possible mechanism that link the anomalous large-scale environments with biomass burning. When abnormal high pressures over northeast Asia, enhanced weaker jet stream cause the warm advection over northeast Asia and Siberia. And the melting of Eurasian snow cover in spring become rapid, then it is favorable condition for biomass burning. And aerosols emissions relatively increase. These mechanisms are also relative to interannual oscillation pattern like ENSO and AO. The El Nino-Southern Oscillation (ENSO) exhibits a significant negative correlation in the recent period of 1998-2015, but the Arctic Oscillation (AO) has no statistical relationship.

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Simulations of Quasi-global Atmospheric Transport of Radionuclides from the Fukushima Daiichi Nuclear Disaster and its Arrival in South Korea

Hyuckjae Lee (Ulsan National Institute of Science and Technology)
Myong-In Lee (Ulsan National Institute of Science and Technology)
Dongmin Kim (Ulsan National Institute of Science and Technology)

On 11 March 2011, the earthquake of 9.0 magnitude scale, which was the largest that Japan had experienced since AD 869 (Minoura et al., 2001), occurred 180km off the coast of the first Fukushima Daiichi nuclear power plant (NPP). As a result of the serious disaster, radioactive materials from the hydrogen and vapor blasting were released into atmospheric boundary layer. Following the release of large amounts of radionuclides from the damaged Fukushima Daiichi NPP, Korea Institute of Nuclear Safety (KINS) reported that the radioactive materials were detected in korean peninsula and adjacent areas. In this study, we construct a modeling framework for atmospheric dispersion of radionuclides based on the WRF-chem model in order to numerically reproduce nuclides transport for the Fukushima Daiichi accident case. Follow up the modeling framework, it validates with existing modeling studies to examine the model dependency and uncertainty in the simulation. In addition to validation with other studies, it examines feasibility of the model simulation by comparing with local radioactivity observation network data in South Korea.

P-126

Algorithm for retrieval of aerosol optical properties over the East Asia from Geostationary Environment Monitoring Spectrometer (GEMS)

Sujung Go (Yonsei University)
Jhoon Kim (Yonsei University)
Mijin Kim (Yonsei University)
Myungje Choi (Yonsei University)
Hyunkwang Lim (Yonsei University)

An aerosol retrieval algorithm for the Geostationary Environment Monitoring Spectrometer (GEMS) to be launched in March 2019 is presented. The algorithm retrieves aerosol optical depth (AOD) and single scattering albedo (SSA) at 443 nm, Aerosol Index, and aerosol effective height. All the products are retrieved except over cloud and sun-glint due to the advantage of low surface reflectance in UV channel, while only Aerosol Index is retrieved over all measurement area. To develop optimized algorithm for the target area of GEMS, optical properties of aerosol are analyzed from extensive observation of AERONET sunphotometers to generate lookup table. The algorithm uses the optimal estimation (OE) method to reduce the retrieval uncertainty induced by assumption of aerosol loading height. The algorithm retrieves a priori states of AOD and SSA at 443 nm by using two channel lookup table approach, and the a priori states are applied to find the optimized solution of AOD, SSA and aerosol effective height by minimizing difference between measured and simulated spectrum. An advantage of the algorithm lies in the self-sufficiency in a priori state of AOD and SSA. By applying the present algorithm to OMI top-of the atmosphere normalized radiance, different aerosol cases dominated by anthropogenic aerosol contains black carbon (BC), dust, and non-absorbing aerosol are analyzed to test the algorithm. The algorithm retrieves AOD, and absorption information together with aerosol layer height which are consistent with results inferred by RGB image in a qualitative way. We evaluate the algorithm results using ground-based AERONET level 2.0 products obtained from 24 sites located in East Asia. We perform this verification for 3 years from January 2005 to December 2007. Preliminary comparison results for total 24 sites show that a correlation coefficient between GEMS and AERONET AODs at 440 nm channel is 0.746, and root-mean-square error (RMSE) is 0.394. The correlation coefficient between GEMS and AERONET AOD shows comparable value to the correlation coefficient between OMI and AERONET AOD. Also, monthly time series of GEMS AOD shows reliable results compared to those of AERONET AOD. We analyzed the difference between GEMS and the AERONET AOD related to the variation of scattering angle, fine mode fraction, spectral surface reflectance, and total precipitable water. Validation results show slight overestimation especially for dust AOD over scattering angle of 140 degree possibly due to mie calculation of dust lookup table, while show weak dependence on spectral surface reflectance. In terms of fine mode fraction and total precipitable water, AOD biases are close to zero.

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Atmospheric Aerosol Reanalysis Over East-Asia based on Cycling Analysis of Three-Dimensional Data Assimilation

Ganghan Kim (Ulsan National Institute of Science and Technology)
Myong-In Lee (Ulsan National Institute of Science and Technology)

Previously, many of the studies are subjected about the data assimilation and the atmospheric chemicals. Generally, data assimilation method is widely used to provide the improved, accurate analysis and forecast meteorological data to the end-users. This method is moved on to the chemical area, to derive the full-motion and concentration of the atmospheric chemicals. In general, chemical and aerosol concentration and species are observed and sampled by satellite installments and surface monitoring stations. To overcome the spatial and temporal limitation of the observation, data assimilation is increasingly demanded. Furthermore, in East Asia, the particulate matters and aerosols transported from desert of the China is seriously impacting to the atmospheric quality of China, Korea, and Japan. In 2011, the satellite named as Communication, Ocean, and Meteorological Satellite (COMs) has been launched, which is stationary orbit satellite continuously observes meteorology and ocean over the Korean region. Scientists in Yonsei University has constructed the algorithm to extract the aerosol optical depth (AOD) in 550 nm wavelength from Geostationary Ocean Color Imager installed on COMs. Adapting the GOCI AOD data, the aerosol data assimilation and generating analysis has been done.

In data assimilation, there are several methods categorized by based ideas, in this study, the variational data assimilation system has been selected. Variational data assimilation considers both model background and observation instrumental errors. For the atmospheric data assimilation, 3D-Var method is the most basic method in the variational method. 3D-Var assimilates the data for one designated time. Currently, most of the common data assimilation systems do not provide the assimilating module of aerosol, but Gridpoint Statsitical Interpolation (GSI) system, which is developed by NCAR/NOAA and DTC, provides the aerosol data assimilation for GOCART aerosol after version 3.4. To generate this background data, Weather Research and Forecasting (WRF)-Chem model has been adapted. WRF-Chem is community model which is specialized to generate regional meteorology/chemical transport, adapted version is 3.5.1. The domain includes China, Korea, Japan, and south of Mongolia, to analyze the transport of aerosol particles from desert to Pacific Ocean, through the China, Korea, and Japan. The analyzing period is DRAGON-Asia period from March 2012. For the comparison, MERRA2 reanalysis data has been selected. GOCI only covers Korean Peninsula and surroundings, the spatial average AOD has been compared to the reference data.

The purpose of this study is finding the appropriate data assimilation cycling period to generate the nearest to the AOD observation. The experiment has been done with the cycling assimilation, which is repeat the assimilation and simulation of WRF-Chem for every 12-hour. The primary result from data assimilation become improved than raw-background data, which is close to the observation. Comparing the analysis data between cycled analysis and single analysis, the cycled analysis shows less bias than single analysis, because the variational data assimilation is considering both background and observation states. The enhanced background state generates better quality of the reanalysis by repeated data assimilation. The result showed that the aerosol concentration has been increased after 5-6 days of cycling simulation, which is close to the observation and reference data. However, the continuous data assimilation also generates overestimation of the aerosol after 8-9 days.

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Ceilometer-Derived Planetary Boundary Layer Height and Air Pollutant Concentrations in Seoul Metropolitan Area during May-June 2016

Junhong Lee (Yonsei University)
Je-Woo Hong (Yonsei University)
Keunmin Lee (Yonsei University)
Jinkyu Hong (Yonsei University)
Yong-Jae Lim (National Institute of Environmental Research)
Jae-Bum Lee (National Institute of Environmental Research)

Planetary boundary layer height (PBLH) is a key factor in the control of the temporal variation of air pollution through dilution via volume change and mixing with the free atmosphere. It is important to quantify the PBLH effect on air pollution for better prediction of air quality. Recent improvements of remote sensing techniques permit high temporal and continuous measurement of PBLH. In particular, a ceilometer is an ideal instrument for measurement of PBLH because of its large range of detection with high vertical resolution. However, few studies have evaluated ceilometer PBLH retrieval algorithms or explained how to determine parameter values in the retrieval algorithms. In this presentation, we report high temporal continuous PBLH from a ceilometer by proposing a new procedure and its relationships with air pollution in Seoul metropolitan area.

P-129

A Study on the Estimation of Inflow Wind Speeds

Geon Kang (Pukyong National University)
Jae-Jin Kim (Pukyong National University)
Dongju Kim (Pukyong National University)

This study investigated the characteristics of flow around the AWS 942 located in the Pukyong national university and established formulas estimating inflow wind speeds at the boundaries of the CFD model domains. Around the AWS 942, there are a lot of buildings that are higher than the observation altitude. Thus, simulated wind speeds at the AWS 942 decreased compared to inflow wind speeds except for the northerly case. In most cases, the AWS 942 was located in the wake regions on the leeward of the buildings. Especially in the easterly cases, the wind speeds of the AWS 942 were simulated to be less than 15% of the inflow wind speeds due to the flow disturbance by the buildings. In order to estimate the wind speeds at the inflow boundaries of the CFD model domain, we conducted simulations by systematically increasing inflow wind speeds (1 m s-1 ～ 17 m s-1 with interval of 2 m s-1) at the reference height for 16 inflow directions and compared the simulated wind speeds at the AWS 942 with the inflow wind speeds and For each inflow direction, the simulated wind speeds at the AWS 942 were fitted as the third order functions of the inflow wind speeds by using the Marquardt-Levenberg least square method. For validation of the estimated formulas, we compared the estimated inflow wind speeds with wind speeds observed at 12 coastal AWSs located within a radius of 60 km from the AWS 942. The results showed that the observed wind speeds at the AWS 942 were similar to those at the lower outlier of coastal AWS, which was attributed to the buildings around the AWS 942. On the other hand, the estimated wind speeds fell within the inter quartile range of wind speeds observed at 12 coastal AWSs during the nighttime and were in close proximity to the upper whiskers during the daytime (12～15 h). This study showed that the observed wind speeds at the AWSs in urban areas are affected by nearby buildings and artificial structures.

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Retrieval of aerosol optical properties from AHI measurements: Impact of surface reflectance assumption

Hyunkwang Lim (Yonsei University)
Myungje Choi (Yonsei University)
Jhoon Kim (Yonsei University)
Sujung Go (Yonsei University)
P.W. Chan (Hong Kong Observatory)
Yasuko Kasai (National Institute of Information and Communications Technology)

Japan Meteorological Agency (JMA) successfully launched the next-generation geostationary satellite called Himawari-8 in 7 October 2014 and started a formal operation in 7 July 2015. The Advanced Himawari Imager (AHI) sensor having 16 channels (from 0.47 to 13.3 μm) is the next-generation geostationary satellite that observes the full disk every 10 minutes. This study attempts to retrieve the aerosol optical properties (AOPs) based on the spectral matching method, with using three visible and one near infrared channels (470, 510, 640, 860nm). This method requires the preparation of look-up table (LUT) approach based on the radiative transfer modeling. Cloud detection is one of the most important processes for guaranteed quality of AOPs. Since the AHI has several infrared channels, which are very advantageous for cloud detection, clouds can be removed by using brightness temperature difference (BTD) and spatial variability test. The Yonsei Aerosol Retrieval (YAER) algorithm is basically utilized on a dark surface, therefore a bright surface (e.g., desert, snow) should be removed first. Then we consider the characteristics of the reflectance of land and ocean surface using three visible channels. The known surface reflectivity problem in high latitude area can be solved in this algorithm by selecting appropriate channels through improving tests. On the other hand, we retrieved the AOPs by obtaining the visible surface reflectance using NIR to normalized difference vegetation index short wave infrared (NDVIswir) relationship. ESR tends to underestimate urban and cropland area, we improved the visible surface reflectance considering urban effect. In this version, ocean surface reflectance is using the new cox and munk method which considers ocean bidirectional reflectance distribution function (BRDF). Input of this method has wind speed, chlorophyll, salinity and so on. Based on validation results with the sun-photometer measurement in AErosol Robotic NETwork (AERONET), we confirm that the quality of Aerosol Optical Depth (AOD) from the YAER algorithm is comparable to the product from the Japan Aerospace Exploration Agency (JAXA) retrieval algorithm. Our future update includes a consideration of improvement land surface reflectance by hybrid approach, and non-spherical aerosols. This will improve the quality of YAER algorithm more, particularly retrieval for the dust particle over the bright surface in East Asia.

P-131

Long-term change of the static stability over Korea

Dasom Lee (Gwangju Institute of Science and Technology)
Jin-Ho Yoon (Gwangju Institute of Science and Technology)

Particulate matter (PM) or Aerosols in the atmosphere have direct/indirect impact on clouds, radiative forcing and human health (IPCC, 2013). Korea peninsula is located on the prevailing westerlies, resulting in large amount of aerosol transported from neighboring countries including China. On the other hand, meteorological conditions such as wind, temperature, relative humidity and others play an important role in anomalous PM conditions, such as high PM case near surface. In this study, we analyzed long-term changes of meteorological conditions and their linkage with PM over Korea. A couple of recent studies identified importance of the meteorological properties in high PM and haze case (Cai et al., 2017, Zou et al., 2017, and Kim et al. 2017).

The most important meteorological conditions affecting anomalous PM condition are the wind speed near surface and the static stability, i.e., vertical thermodynamic profile. For example, atmospheric inversion or stable stratification affecting wind speed, it could lead to high PM case near surface.

In order to investigate the long-term change of the static stability, we calculated the vertical derivative of potential temperature and 10-m wind speed using modern reanalysis dataset (JRA-55). We found (i) the static stability and wind speed exhibit robust negative correlation, and more interestingly (ii) a steady increase trend is found in the static stability as well as a decrease trend in 10-m wind speed. Finally, it is argued that this long-term change in the static stability is driven by stronger warming in the lower troposphere than the near surface condition, likely due to global warming.

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Characteristics of Recent Severe Haze Event in Korea and Possible Inadvertent Weather Modification

Seung-Hee Eun (Gangneung-Wonju National University)
Byung-Gon Kim (Gangneung-Wonju National University)
Wenting Zhang (Gangneung-Wonju National University)

Precipitation is a key physical process related to weather, climate, and the hydrological cycles. The quantitative understanding of aerosol-cloud-precipitation interactions is still insufficient despite substantial amounts of previous efforts to solve this issue since it has inherent complexity and intertwined nonlinear relationship. Probably we might need overwhelming aerosol forcings well beyond natural cloud and precipitation variabilities in order to identity and attribute its discernible effect on clouds and precipitation. Korea has recently suffered from severe air pollution and extreme haze, which could further impact not only public health but also meteorology and hydrological cycles. Most severe haze episodes appear to be largely long-range transported from China, which could be made the best use of to evaluate the hypothesis of enhanced aerosol impacts on clouds and precipitation. We demonstrate several evidences of aerosol impacts on clouds and precipitation, and briefly conduct numerical simulations to explain the possible modification of clouds and precipitation with a special emphasis on January 2013.

Eight severe hazes in 2011 to 2013 were observed in the mid-Korean peninsula. In general, the clouds systems overlapped with aerosol plumes seemed to be modified such that drizzle-type light precipitation lasted longer (or delayed) within a day than the operational weather forecast because precipitation might be extended at a less rate due to increases in number concentration of smaller cloud droplets as shown by a sensitivity test using the WRF model. This study shows a possible evidence of inadvertent weather modifications by enhanced aerosols with observational evidences and model results.

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Characteristics of aerosol in-situ and column optical properties observed in Asian continental outflow from 2012 to 2014

Soojin Park (Seoul National University)
Sang-Woo Kim (Seoul National University)
Patrick Sheridan (GMD/ESRL National Oceanic and Atmospheric Administration)
John Ogren (GMD/ESRL National Oceanic and Atmospheric Administration)
Elisabeth Andrews (GMD/ESRL National Oceanic and Atmospheric Administration)
Neng-Huei Lin (National Central University)
Jeong Eun Kim (National Institute of Meteorological Sciences)
Ji-Hyoung Kim (Seoul National University)
Soon-Chang Yoon (Seoul National University)

We analyzed ground-based in-situ measurements of aerosol optical properties (AOPs), column aerosol optical depth (AOD) and size distribution at three sites [Anmyeon (AMY) and Gosan (GSN), Korea and Lulin (LLN), Taiwan] from 2012 to 2014. Total mean scattering coefficient (σsp) and absorption coefficient (σap) (in parenthesis) for sub-10 μm particles was largest at AMY with values of 133.89 Mm-1 (11.46 Mm-1) and smallest at LLN of 35.66 Mm-1 (3.26 Mm-1). Seasonal variations of σsp and σap were similar at AMY and GSN, with high values in spring, due to frequent Asian dust episodes, and early summer, due to increase of local emissions and stagnant meteorological conditions resulting in build-up of aerosols. On the other hand, σ sp and σap at LLN showed little month to month variation apart from elevated values in spring. The peak of AOPs in March and April at LLN can be mainly attributed to transport of biomass burning aerosols from northern Indochina. Single scattering albedo (ω) showed similar mean values at all three sites (0.91, 0.93, and 0.91 in the order of AMY, GSN, and LLN) and a similar seasonality where ω peaked during summer, due to the influence of ocean aerosols. Scattering Ångström exponent (SÅE) showed little month to month variation while absorption Ångström exponent (AÅE) showed minima in summer at all three sites. The month to month variation of AERONET AOD were similar to those of ground-based in-situ extinction coefficient (σep) for each site. Peaks in supermicron particles observed in spring at all three sites can be attributed to Asian dust particles. However, as we discussed above, elevated submicron particles at LLN during March and April can be explained by the biomass burning aerosols transported from northern Indochina.

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Aerosol Number Size Distribution and Type Classification from 4-Year Polarization Optical Particle Counter (POPC) Measurements in Seoul

Hyeon-Ju Park (Seoul National University)
Sang-Woo Kim (Seoul National University)
Hiroshi Kobayashi (University of Yamanashi)
Tomoaki Nishizawa (National Institute for Environmental Studies)

The Polarization Optical Particle Counter (POPC) measures not only particle number and size but also depolarization ratio (DPR; the sphericity information of single particle) for 4 channels (0.5-1, 1-3, 3-5, 5-10 μm), so that the POPC, unlike general OPC, has the advantage of being able to classify aerosol types such as anthropogenic pollution, mineral dust. In this study, we investigated the temporal variations of particle number and volume size distributions with DPR and classified aerosol types from 4-year (2013-2016) POPC data at Seoul National University campus, Seoul, Korea.

Non-spherical coarse mode particles (5 < Dp (particle diameter) < 10μm) with relatively high DPR (0.25-0.3) were apparent in both spring (MAM) and winter (DJF) due mainly to the frequently transported Asian dust particles. During the summer (JJA), however, both particle number concentration (N_c) and DPR (δ) were decreased in all size bins due to the frequent precipitations and influences of relatively clean maritime airmass. The lowest aerosol number concentrations were observed in all size bins in autumn (SON).

To classify the aerosol types, we firstly investigated aerosol number, volume size distributions and DPR for clean, anthropogenic pollution-dominant and dust-dominant cases, which were designated by PM2.5, PM10 mass concentrations. The anthropogenic pollution-dominant periods were characterized by $\bar{\delta} \leq 0.09$ and $\bar{N}$_c^(D_p< 1 μm). Whereas, $\bar{\delta}$ and $\bar{N}$_c^(D_p>1μm) during dust-dominant periods were greater than 0.2 and 280 L-1 in coarse mode particles (Dp > 1μm), respectively.

When we applied these criteria to the extreme pollution-Asian dust event during February 22-24, 2015, we found that pollution-dominant airmass ($\bar{\delta}$=0.09, $\bar{N}$_c^(D_p1μ m)=2472 L-1). The co-located Mie-scattering polarization aerosol lidar measurements also showed that spherical pollution particles appeared near the surface prior to the major non-spherical mineral dust plume.

P-135

Polarization characteristics in UV-VIS region by using the radiative transfer model for GEMS/GK-2B: Model development and analysis of Asian dust

Haklim Choi (Kyungpook National University)
Kwang-Mog Lee (Kyungpook National University)

The radiative transfer model for GEMS/GK-2B (Geostationary Environment Monitoring Spectrometer) can be used as a simulation tool in the development of data processing algorithms. For example, it could be used in the production of synthetic data required for validation or correction of the data processing algorithms.

GEMS RTM can be set to calculate normalized radiance for each component of Stokes parameter, using vector or scalar for a Rayleigh atmosphere with absorbing gases such as O3, NO2, SO2, H2CO, and O4. Lorenz-Mie theory has been used to calculate the single scattering properties of clouds and aerosols such as emissivity, scattering, absorption, single scattering albedo and phase function. The scalar mode brings out the difference up to 8% for the radiance in comparison with the vector mode. And these absolute differences are greatly influenced by the polarization effects of the ozone.

In a given Rayleigh simulating condition, DOLP (Degree of Linear Polarization) is, on average, about 0.5 throughout the spectral region. From 0.3 to 0.5 μm, the DOLP tends to be somewhat weakened at longer wavelengths. This can be explained by the effect of multiple scattering.

Furthermore, when aerosols are loaded in the atmosphere, the scattering characteristics differ depending on the type of aerosol. This is evident from the experimental results of OPAC (Optical Properties of Aerosols and Clouds) classification of aerosols. In particular, the polarization characteristics such as DOLP and DOCP (Degree of Circular Polarization) are different even in the case of the dust type having a similar phase function.

Acknowledgment: This subject is supported by Korea Ministry of Environment (MOE) as Public Technology Program based on Environmental Policy (2017000160001)

P-136

Contribution of long-range transported aerosols on PM10 mass concentration in Seoul, Korea: An observation-based estimate

Do Hyeon Park (Seoul National University)
Sang Woo Kim (Seoul National University)

We estimated the contribution of long-range transported (LRT) aerosols on particulate air quality in Seoul by using PM10 concentration measurements at mountain-top (Mt.Gwanak; 622.4 m amsl) and near-surface city-centered (Songwol; 85.8 m amsl) sites over the period of 2008-2015. Overall mean PM10 concentration at Mt. Gwanak (hereafter, PMG) and Songwol (hereafter, PMS) sites were estimated to be 47±42 ug m-3 and 49±39 ug m-3, respectively. Especially, PMG (43 ±44 ug m-3) was about 6 g m-3 lower than PMS (49±40 ug m-3) during the nighttime. This is because Mt. Gwanak site can be mostly located above mixing layer height (MLH) during the nighttime. However, PMG during the nighttime was equal to or often higher than PMS. As revealed by 11-year continuous lidar observations from 2006 at Seoul National University, this is attributable to the presences of thick aerosol layers from surface to 1-2 km altitude on high-PM10 episode days. In this study, we estimated the contribution of LRT and local aerosols on PM10 concentration for the following conditions: nighttime only, PMS > 50 ug m-3, and PM (PMG - PMS) > - 6 ug m-3. Overall contribution of LRT on high-PM10 days was about 41%. The LRT contribution increased up to 41% and 47% in winter and spring respectively under prevailing northwesterly winds, but decreased about 32% during the summer due to increased influences of clean maritime airmass. This observation-based calculation of the contribution of LRT aerosols on PM10 concentration in Seoul is somewhat lower than that estimated by chemical transport models (Kim et al., 2016, J. Korean Soc. Atmos. Environ.; Koo et al., 2008, AE).

P-137

Global and regional climate impact of interactive ozone and aerosols from a new coupled chemistry-climate model

Seungun Lee (Seoul National University)
Rokjin J. Park (Seoul National University)
Sang-Woo Kim (Seoul National University)
Seok-Woo Son (Seoul National University)
Jae-Jin Kim (Pukyong National University)
Byung-Gon Kim (Gangneung-Wonju National University)
Byung-Kwon Moon (Chonbuk National University)
Sang-Wook Yeh (Hanyang University)

We use a newly developed coupled chemistry-climate model (GRIMs-Chem) to investigate the global and regional climate impact of interactive ozone and aerosols. The model is a coupled model of the Global/Regional Integrated Model system (GRIMs) and an offline aerosol module from the GEOS-Chem chemical transport model. The model is capable of simulating tropospheric aerosols including secondary inorganic sulfate-nitrate-ammonium aerosols with prescribed total nitrate and atmospheric oxidants, and primary organic carbon, black carbon, sea salt, and soil dust aerosols. The model also simulates stratospheric ozone with a simple linearized ozone chemistry (LINOZ), in which the ozone production rate is linearized to the temperature and the local and overhead column ozone concentration. The simulated ozone and aerosol concentrations are used in the radiative transfer calculation in the model to account for the direct radiative forcing of ozone and aerosols. We conducted two 32-year model simulations from 1979 to 2010 with and without interactive ozone and aerosols to estimate the direct radiative forcing of ozone and aerosols. We evaluate the simulated column ozone concentration and aerosol optical depth by comparing with the satellite measurement. The comparison shows that the model captures the observed spatial and temporal variation of column ozone and aerosol optical depth. We analyze the effect of ozone and aerosols on global and regional climate by comparing the two simulation results and find that the stratospheric ozone reduced the temperature cold bias of the model in the stratosphere and the aerosols in East Asia could make perturbations in the atmospheric stability resulting in the changes of precipitation.

P-138

Effect of nitryl chloride chemistry on oxidation capacity in East Asia

Hyeonmin M. Kim (Seoul National University)
Rokjin J. Park (Seoul National University)
Jaein I. Jeong (Seoul National University)
Saewung Kim (University of California)
Seogju Cho (Seoul Metropolitan Government Research Institute of Public Health and Environment, Microbiology Team)

Nitryl chloride (ClNO2) plays an important role as a nighttime reservoir of NOx and the source of Cl radical, which affects the oxidation capacity of the atmosphere. However, most of air chemistry models do not consider ClNO2 chemistry in the troposphere. In order to examine the impact of ClNO2 chemistry on oxidation capacity in East Asia, we include it in a global 3-D chemical transport model, GEOS-Chem and conduct model simulations focusing on KORUS-AQ campaign for May-June, 2016. Extensive observations from the KORUS-AQ campaign are used to validate model results. We find the consideration of ClNO2 chemistry in the model results in an increase of ozone and NOx by about 5 ppbv, 7 ppbv, respectively and a decrease of TNO3 (HNO3 + aerosol nitrate) by about 3 μg m-3 in Korea during the KORUS-AQ campaign, resulting in a better agreement with the observations at Olympic Park.

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Evaluation of simulated VOCs during the KORUS-AQ campaign and its effect on secondary pollutants formation in Korea

Yujin Ok (Seoul National University)
Rokjin J. Park (Seoul National University)
Donald R. Blake (University of California at Irvine)
William H. Brune (Pennsylvania State University)
Andrew J. Weinheimer (National Center for Atmospheric Research)
Alan Fried (University of Colorado Boulder)

Volatile Organic Compounds (VOCs) play an important role as a precursor of aerosols and ozone, which are key secondary air pollutants. Therefore, the ambient concentration and emission of VOCs is an important database for 3-D air chemistry models to produce daily air quality information. However, the observations of VOCs are relatively sparse in Korea and cause one of critical uncertainties in their sources and chemical formation in the model. We here use a 3-D global chemistry transport model (CTM), GEOS-Chem, and the extensive observations of VOCs during the Korea-US Air Quality (KORUS-AQ) campaign, which occurred in May-June, 2016 to examine the role of VOCs chemistry in secondary air pollutants formation. During the KORUS-AQ campaign, aircraft observations of VOCs were conducted onboard the NASA DC-8 aircraft, using the Whole Air Sampler (WAS), which provides high frequency measurements of biogenic and anthropogenic VOCs such as isoprene, alkanes, alkenes and aromatic hydrocarbons (benzene, toluene etc.). We find that the observed aromatic species, especially toluene, have relatively high concentrations in Korea compared to the observations in other global regions. Inclusion of a detailed toluene chemistry in the model results in an improved agreement of simulated secondary pollutant concentrations with the observations, indicating the importance of aromatic chemistry for secondary pollutants formation in Korea.

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Aircraft GeoTASO HCHO column density measurements with high spatial resolutions for KORUS-AQ campaign

Hyeong-Ahn Kwon (Seoul National University)
Rokjin J. Park (Seoul National University)
Caroline R. Nowlan (Center for Astrophysics)
Gonzalo Gonzalez Abad (Center for Astrophysics)
Kelly Chance (Center for Astrophysics)
Scott J. Janz (NASA Goddard Space Flight Center)
Alan Fried (University of Colorado Boulder)

Formaldehyde (HCHO) is a key chemical link with volatile organic compounds (VOCs), which are important precursors for ozone production. Thus, HCHO column density has been measured from sun-synchronous satellites to constrain VOCs emissions and to diagnose VOC-limited or NOx-limited regimes for ozone production. However, HCHO satellite measurements such as OMI are limited in providing local source information of anthropogenic VOCs because of coarse pixel sizes (13 km x 24 km) and measurement frequencies (at most once or twice a day). Alternatively, aircraft instruments can be used to provide local source information with high spatial and temporal resolutions of measurements and further to provide observational constraints for validating an algorithm for geostationary satellites. Here we use radiance measurements from the Geostationary Trace gas and Aerosol Sensor Optimization (GeoTASO) instrument for KORea-United States Air Quality Study (KORUS-AQ) campaign to investigate local sources of HCHO in Korea and to evaluate a prototype algorithm of HCHO for Geostationary Environmental Monitoring Spectrometer (GEMS) over East Asia. GeoTASO on-board NASA King Air B200 measures backscattered ultraviolet (UV) and visible radiances in two channels with fine spatial resolutions of 13-15 m x 50-80 m for KORUS-AQ campaign. For the radiance fitting in HCHO retrieval, we use a non-linear fitting method (BOAS), with the fitting window of 328-357.7 nm in UV channel, where HCHO absorption is dominant with minimum ozone interferences. Our retrieval results of GeoTASO observations show pronounced HCHO enhancements over crop lands cultivating rice in Korea, which are likely produced by methane oxidation and primary emissions from crop burning. As temperature increases from May to June, we find HCHO increases in mountainous regions, indicating active isoprene emissions in the warm season. More extensive analysis using the retrieved data over Daesan provides information for anthropogenic VOCs emitted from refinery companies, power plants, and industrial complex. As validation, we compare our retrieved HCHO column with in-situ HCHO concentrations from DC-8 aircraft and find a linear relationship between column density and volume mixing ratio, indicating successful retrievals applied to GeoTASO data using our algorithm for GEMS during KORUS-AQ campaign.

P-141

Impact of plant functional type change on isoprene emission and the implication for surface ozone simulation over Korea

Heesoo Jang (Seoul National University)
Rokjin J. Park (Seoul National University)
H.K. Kim (National Institute of Environmental Research)
Alex B. Guenther (University of California at Irvine)
Donald R. Blake (University of California at Irvine)
Andrew J. Weinheimer (National Center for Atmospheric Research)

Isoprene, one of highly reactive biogenic VOCs (BVOCs), is important for ozone formation. The estimates of global and regional isoprene emissions from vegetation, however, are highly uncertain. Among several factors, plant functional type (PFT) is one of key factors, determining biogenic isoprene emissions, and thus is important for surface ozone simulations. Relatively coarse PFT database has been used in most chemical transport and air quality models including GEOS-Chem, which has used 1°x1° PFT data from the CLM4 (Community Land Model version 4). In this work, we update PFT data in GEOS-Chem using much finer resolution Korean PFT (KORPFT) data (150m x 150m) from Korea Forest Research Institute to understand the role of vegetation input in ozone simulations. For evaluation of the model performance, we use NASA DC-8 aircraft observations of VOCs from the Korea-US Air Quality (KORUS-AQ) campaign, which was conducted in May to June 2016. We found that the daily mean surface ozone level decreased by about 1～5 ppbv over the Taebaek Mountains and ozone level increased by about ～2 ppbv over the west side of Korea (e.g. Seoul and the part of Chungcheong / Jeolla province). These changes are due to the overall decrease of broadleaf trees and increase of needleleaf trees over Korea. Also, we found that the change of the needleleaf tree subcategory can alter the isoprene emissions by a factor of 1.5, implying that the distribution of specific species from needleleaf trees can be very important for regional ozone simulations.

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Analysis for the Transport to Stagnation of Vertical Aerosol Mass Concentration in Seoul and Gangneung during Jan.-Feb., 2015

A-Reum Ko (National Institute of Meteorological Sciences)
Ki-Ho Chang (National Institute of Meteorological Sciences)
Eunsil Jung (National Institute of Meteorological Sciences)
Huidong Yeo (Seoul National University)
Beomchel Shin (National Institute of Meteorological Sciences)
Sang-Woo Kim (Seoul National University)
Byung-Gon Kim (Gangneung-Wonju National University)
Baek-Jo Kim (National Institute of Meteorological Sciences)

The purpose of this study is to investigate the vertical distribution of aerosol mass concentrations in Seoul and Gangneung during Jan.-Feb. in 2015. The vertical aerosol mass concentration is calculated by using the standard algorithm provided by KALION (Korea Aerosol Lidar Observation Network). The calculated aerosol mass concentrations of two regions were evaluated through comparison with ground-level PM10 concentration (R2=0.90, 0.93 for Seoul and Gangneung, respectively). The average vertical aerosol mass concentrations of Seoul and Gangneung were similar to 3.60 μg m-3 and 3.39 μg m-3 in altitudes from 1 to 6 km, respectively. In contrast, the average aerosol mass concentrations at lower altitude (< 1 km) was 41.71 μg m-3 (in Seoul) and 31.66 μg m-3 (in Gangneung), which Seoul was higher about 10 μg m-3 than Gangneung region. We used backward trajectory modeling to identify the difference of the aerosol distribution between the two regions below 1 km. Back trajectories were classified into five major clusters, which are one of the stagnant air mass (stay for over 13 hours within 100 km) and air masses of 4 wind directions (east, west, south, north). The air masses came from the west direction was the highest among the five clusters influencing the increase of vertical aerosol concentration in Seoul and Gangneung region. In Seoul, the amount of aerosol mass concentration due to western air inflow is similar to the stagnant air mass, while a considerable difference (about 1.6 times) appeared in Gangneung. It is thought that Gangneung, the small city compared with Seoul, has a relatively larger amount of aerosols.

Acknowledgements: This work was supported by the program, "Research and Development for KMA Weather, Climate, and Earth system Services" of National Institute of Meteorological Sciences (NIMS) funded by the Korea Meteorological Administration (KMA).

Key words: Lidar, Vertical aerosol mass concentration, Back-trajectory of atmosphere, Stagnation, Transport

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Inter-comparison of Antarctic ozone profiles using satellite and ozonesonde observations

Hana Lee (Yonsei University)
Taejin Choi (Korea Polar Research Institute)
Dha Hyun Ahn (Yonsei University)
Jhoon Kim (Yonsei University)
Ja-Ho Koo (Yonsei University)

Stratospheric ozone plays an essential role for ultraviolet radiation absorption, and is closely linked to climate change and atmospheric circulation pattern over the Antarctica and even Southern Hemisphere. Investigation of vertical ozone distribution over Antarctica is an important task for quantifying this stratospheric ozone depletion. In order to examine variability of Antarctic stratospheric ozone, various measurements have been observed the vertical ozone profile. For example, Ozone Monitoring Instrument (OMI) on board the NASA Aura sun-synchronous satellite was launched on July 2004 to continue the long-term record of satellite ozone profile measurements. OMI has officially two independent ozone profile algorithms, called OMIO3 and PROFOZ. Both of algorithms have adopted the optimal estimation inversion technique. PROFOZ retrieval algorithm initially developed at the Smithsonian Astrophysical Observatory (SAO) that has been put into production in the OMI Science Investigation-led Processing System (SIPS), processing the entire OMI data record with approximately one-month delay. It was shown capable of capturing tropospheric ozone signal, and there has the finer vertical resolution than OMIO3 data.

In a local scale, ozonesonde at several Antarctic stations also has measured the in situ ozone profile from surface to about 30-35 km. In spite of same ozone profile measurement, OMI has more frequent measurements and thicker vertical resolution than ozonesonde. From August 2015, the Jang bogo station, which is the second Korean base in Antarctica (Long: 164° 12′E, Lat: 74° 37′S) has been monitoring vertical ozone profile using ozonesonde instrument (Electrochemical Concentration Cell).

This study presents comparisons between ozone profiles retrieved from OMI and ozonesonde for the inter-comparison purpose. To more focus on how the stratospheric ozone pattern can be captured, we used polar spring (September-November) from 2015-2016 data.

For the inter-comparison, first we need to determine the spatiotemporal range of comparison based on the balance between finding most coincident OMI/ozonesonde pairs to minimize their difference. This process is necessary to perform the proper data sampling for statistical analysis. For each screened ozonesonde profile, we first select all filtered OMI data within ± 1° latitude and longitude and ± 6 hours and then find the nearest OMI retrieval within 100 km from the ozonesonde station to perform the validation on the individual profile basis. Second, to resolve the issue of different vertical resolution, ozonesonde profiles are integrated into the corresponding OMI vertical grids and degrade with considering OMI retrieval averaging kernels and a priori ozone profile. The relative difference is calculated for comparison with ozonesonde.

Inter-comparison results indicate that the OMIO3 and PROFOZ show similar pattern in the upper atmosphere, but large relative difference in the troposphere (OMIO3: 94% from 640 hPa, PROFOZ: 58% from 221 hPa). The large error in the troposphere was related to retrieval sensitivity of latitude. The high latitude has the inherent reduction in retrieval sensitivity to lower altitude at larger SZAs as a result of reduced photon penetration into the atmosphere and highest a priori uncertainty. In addition, OMIO3 had a coarse vertical resolution in the lower troposphere, which causes a large error than PROFOZ.