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S3C Presentation

S3C-1

Relationship between black carbon and carbon monoxide obtained from the satellite observations

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Black carbon (BC) and carbon monoxide (CO) is the significant pollutants in the atmosphere associated with the radiative forcing analysis in the global scale. These pollutants are known to have a warming effect, similar to popular greenhouse gases such as carbon dioxide (CO2) and methane (CH4). BC and CO have analogous properties each other, such as the emission source, contribution to the global warming, and so on. Based on this close relationship, there were a number of studies to examine the correlation between BC and CO amounts. While ground-based measurements can provide high-quality and temporally continuous information, there is a limitation due to sparse locations. Therefore, satellite remote sensing is the platform to provide abundant data for regional and global-scale analysis of BC-CO relationship. Recent developments in retrieval algorithms of aerosols and gases with its broad coverage enable us to investigate their relationship in general. Due to the difficulties to retrieve BC AOD from the total AOD, however, correlation analysis between BC and CO using satellite measurements still deserves attention for better figuring out the BC-CO relationship.

In this study, we investigate and compare correlations between CO total column density (TCDCO) from the Measurement of Pollution in the Troposphere (MOPITT) data, and high-absorbing BC dominant aerosol optical depth (AODBC) from the retrieval algorithm using Moderate Resolution Imaging Spectroradiometer (MODIS) and Ozone Monitoring Instrument (OMI) (MODIS-OMI algorithm, MOA) for several regions. TCDCO has positive relationship to both fine-mode AOD (AODFM) and AODBC in general, but TCDCO better correlates with AODBC than AODFM. We find high correlations between TCDCO and AODBC more clearly during spring and summer. Meanwhile, correlation between TCDCO and AODBC is quite poor in Northern Africa. This feature may be because the BC-dominated aerosols are much mixed with mineral dust from the Sahara. Another issue is found in Southern Africa where the intense biomass burning and wildfire appears in general; the correlation between AODBC and TCDCO in this region is not much higher than that between the AODFM and TCDCO. The reason looks to be the cloud effect near the source regions and dispersion effect by regional wind pattern. We can find higher correlations between AODBC and TCDCO when considering the fire detected areas only, meaning the large impact of burning events to the high positive correlation between BC and CO. Results in this study illustrates a possibility to utilize satellite CO observations for the validation of BC-dominated aerosol information of satellite measurements.

Correlation values between AODBC and TCDCO can be utilized to evaluate BC aerosol product obtained from satellite-based aerosol type classification algorithms. For better quantitative understanding, analysis about the height of BC aerosols needs to be more considered in the future because the plume height of BC emission can be different according to the emission sources. Usage of Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) can be helpful to examine the influence of BC type aerosol height to the retrieval of BC aerosols, particularly above the region showing BC particles emitted from biomass burning and anthropogenic emission simultaneously. Additionally, use of geostationary satellite measurements enable us to look into the diurnal cycles of BC-CO

correlations. Recently new geostationary satellite missions are being prepared in three continents together: Geostationary Environment Monitoring Spectrometer (GEMS) in East Asia, Tropospheric Emissions: Monitoring of Pollution (TEMPO) in North America, and Sentinal-4 in Europe. Further study with these missions will improve the quality of BC-dominant aerosols, resulted in the better correlation between BC and CO products.

S3C-2

Modeling Concentrations and Sources of Secondary Organic Aerosols in China

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Secondary organic aerosols (SOA) are formed in the atmosphere from gas-to-particle conversion of volatile organic compounds. Observational studies indicated that SOA accounted for a significant fraction of the observed organic aerosols and the total fine particles (PM2.5) during severe haze events. In this study, SOA module in the Community Multiscale Air Quality (CMAQ) model were updated to include the more detailed description of SOA formation from isoprene oxidation and correction on the yields. The revised model was applied to study the spatial and temporal distribution of SOA concentrations and sources in China in the entire year of 2013. Predicted summer SOA was generally higher (10-15 μg m-3) due to large contributions of isoprene (country average, 61%). Wintertime SOA was slightly lower and was mostly due to emissions of alkane and aromatic compounds (51%). Contributions of monoterpenes SOA were relatively constant (8-10%). Overall, biogenic SOA accounted for approximately 75% of total SOA in summer, 50-60% in autumn and spring, and 24% in winter. In winter, SOA formation was mostly due to anthropogenic emissions from industries (40%) and residential sources (38%). Sichuan Basin had the highest predicted SOA concentrations in the country in all seasons, with hourly concentrations up to 50 μg m-3. Approximately half of the SOA in all seasons was due to the traditional equilibrium partitioning of semi-volatile components followed by oligomerization, while the remaining SOA was mainly due to reactive surface uptake of isoprene epoxide (5-14%), glyoxal (14-25%) and methylglyoxal (23-28%).

Large discrepancy was found in the source contributions when using the Multi-resolution Emission Inventory for China (MEIC) and The Regional Emission inventory in ASia v2.1 (REAS2) emission inventories. Contributions from the transportation sector are predicted to be much more important based on the REAS2 emission inventories (～30-40% vs. ～5%). This discrepancy in source contributions to SOA needs to be further investigated as the country seeks for optimal emission control strategies to fight air pollution. Sensitivity analyses showed that formation of SOA from biogenic emissions was significantly enhanced due to anthropogenic emissions. Removing all anthropogenic emissions while keeping the biogenic emissions unchanged led to total SOA concentrations of less than 1 μg m-3, which suggests that manmade emissions facilitated biogenic SOA formation and controlling anthropogenic emissions would result in reduction of both anthropogenic and biogenic SOA.

S3C-3

Lead isotopic ratios and concentration of trace metal elements of precipitation in Japan

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The chemical composition of precipitation in Japan changes regionally and seasonally. The concentration of trace metal elements in precipitation is known to be high in winter (December-February) and spring (March-April) in Japan Sea side of the islands when the monsoon blows from the Asian Continent. Previous studies have proven that concentration of anthropogenic elements (e.g., lead and arsenic) is influenced by trans-boundary air pollution from the Asian continent. Lead isotope ratios can be used to trace the sources of this pollution because they vary from area to area. To do this, lead isotope ratios of the region of interest can be compared to that of other regions. Previous studies have proven that lead in precipitation in Japan is influenced by that of northern China and Korea. In some region in southern Japan, southern China exerts its influence in addition to that of Northern China and Korea. However, these previous studies reached a conclusion based on a few sample points. As at now, no study has been carried out using many samples taken from the whole of Japan to prove the present situation of trans-boundary air pollution. Therefore, in this study, the results of trace metal elements and lead isotope ratios (208Pb/207Pb, 206Pb/207Pb) of precipitation sample collected in the whole of Japan (42 spots), from January to December, 2013 was used. The objective of this study was to sort local characteristic by statically analyzing concentration of trace metal elements, and to trace the origin of trans-boundary air pollution based on lead isotope ratios by using precipitation samples.

The concentration of trace metal elements (lead, arsenic, cadmium, antimony, neodymium and cesium) is known to be relatively high in the Japan Sea side of Japan in winter and spring. However, that of the Pacific Ocean side of Japan is low all year round. Combustion of coal releases these anthropogenic elements into the atmosphere. Because the Asian continent is growing fast economically, it uses a lot of coal. Thus, in the Japan Sea side of Japan, concentration of the above elements may become higher because of winds blowing from the Asian continent in winter and spring.

From this study, 208Pb/207Pb and 206Pb/207Pb values of precipitation in Japan were in the ranges of 2.385～2.471 and 1.110～1.182 respectively. Both lead isotope ratios showed high values in winter and spring. However, many of the precipitation showed low values in summer (June-August) and fall (September-November). The lead isotopic ratios of Japan's precipitation were compared to that of aerosol from precious studies carried out on East Asia. Northern China and Korea's lead isotopic ratios range of aerosol contained the isotopic range of lead in precipitation of the Sea of Japan side of northern Japan. In contrast, the isotopic range of lead precipitation in the Sea of Japan side of western Japan for the same period was intermediate between northern China-Korea's range and southern China's range. Monsoon blows from the Asian Continent to Japan in winter and spring. Thus, anthropogenic elements (e.g., lead and arsenic) in the Sea of Japan side of northern Japan may be influenced by that of Northern China and Korea. In addition, anthropogenic elements in the Sea of Japan side of western Japan may also be influenced by that of southern China. In contrast, the isotopic seasonal variation of lead in precipitation in the Pacific Ocean side of Japan was lower than that of the Sea of Japan side. This implies that the influence from East Asia may be relatively small in the Pacific Ocean side of Japan.

S3C-4

Evaluations of ground-level NO_2 volume mixing ratios inferred from total column observations of Pandora spectrometer

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Nitrogen dioxide (NO_2) plays a key role in atmospheric chemistry and air quality. In terms of chemical reactions, it is one of precursors associated with various air pollutants including tropospheric ozone (O_3). From a human health perspective, chronic exposure to NO_2 can cause respiratory effects. It is therefore important to monitor NO_2 with high temporal resolution and large spatial coverage to capture its spatiotemporal variability. In recent years, column amounts of NO_2 have been observed on a global scale from Low Earth Orbit (LEO) satellite-borne sensors such as Global Ozone Monitoring Experiment (GOME), Scanning Imaging Absorption Spectrometer for Atmospheric Chartography (SCIAMACHY), Ozone Monitoring Instrument (OMI), and GOME-2. Owing to the measurement property, however, LEO instruments have their limitation in capturing temporal variability of NO_2 on a diurnal scale. In contrast to LEO, geostationary orbit (GEO) satellite can observe diurnal variations of NO_2 column amounts during the daytime with continental coverage. Several GEO satellite missions will be started in coming years such as Geostationary Environmental Monitoring Spectrometer (GEMS), Tropospheric Emissions: Monitoring of Pollution (TEMPO), and Sentinel-4. In a ground level, Pandora spectrometer has been installed for the validation with these GEO observations as well as local air quality monitoring. Since the air quality monitoring is mostly important at the surface level, we need to execute the conversion of these NO_2 column measurements to ground-level volume mixing ratio (VMR).

National Institute of Environmental Research (NIER) in Korea and National Aeronautics and Space Administration (NASA) in the United States performed the Korea U.S.-Air Quality (KORUS-AQ) campaign in 2016 over the Korean peninsula to understand air pollution monitoring. During the KORUS-AQ campaign, nine Pandora instruments were installed for the column measurements of trace gases including NO_2. Pandora spectrometer, a ground-based remote sensing instrument covering the spectral range 280-525 nm, measures total column amounts of trace gases in the atmosphere. Major chemical species observed by Pandora are NO_2 and O_3. It is possible for Pandora to capture diurnal variations.

To estimate ground-level NO_2 VMR from Pandora

NO_2 column measurements, we need accurate information of planetary boundary layer (PBL) height and NO_2 number density within PBL. For PBL height (PBLH) values, we use three different datasets: (1) ceilometer observations, (2) GEOS-Chem model, and (3) European Centre for Medium-Range Weather Forecasts (ECMWF) Reanalysis-Interim (ERA-Interim). To extract number density of NO_2 within PBL from total column measurements, we use (1) OMI stratospheric NO_2, (2) GOME-2 stratospheric NO_2, and (3) vertical profile of NO_2 from Goddard Earth Observing System-Chemistry model (GEOS-Chem). We then compare the results from different combinations of the datasets.

Estimated VMRs are evaluated with in situ surface measurements obtained from Air Korea network managed by Ministry of Environment in Korea. The agreement between Pandora-derived VMRs and Air Korea measurements are assessed based on correlation analysis. Correlation coefficients are spatially different and depend on how to obtain the VMR in PBL, ranging from 0.32 to 0.87.

S3C-5

Impacts of historical climate and land cover changes on tropospheric ozone and particulate matter in East Asia

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To examine the effects associated with changes in climate, land cover, land use, and anthropogenic emissions on surface ozone and PM2.5 between the 5-year periods 1981-1985 and 2007-2011 in East Asia, we perform a series of simulations using a global chemical transport model (GEOS-Chem) driven by assimilated meteorological data and a suite of land cover and land use data. Our results indicate that land cover change alone could lead to a decrease in summertime surface ozone by up to 4 ppbv in East Asia, driven mostly by enhanced dry deposition resulting from climate and CO2-induced increase in vegetation density, which more than offsets the effect of reduced isoprene emission arising from cropland expansion. Climate change alone could lead to an increase in summertime ozone by 2-10 ppbv in most regions of East Asia, mostly attributable to warming. The combined impacts show that while the effect of climate change on ozone is more pronounced, land cover change could offset part of the climate effect. Climate change alone could lead to a decrease in wintertime PM2.5 concentrations by 4-12 μ g m-3 in north China, but to an increase in summertime PM2.5 by 6-8 μ g m-3 in those regions between the two periods. The impact of land cover and land use alone on PM air quality (-2.1 to +1.3 μ g m-3) are smaller than that of climate change, but among the various components the sensitivity of secondary organic aerosol (SOA) and thus organic carbon to land cover change (-0.4 to +1.2 μ g m-3) is quite significant especially in summer. As a result of both climate and land cover changes combined, PM2.5 level are estimated to change by -12 to +12 μ g m-3 across East Asia between the two periods. The changes in anthropogenic emissions remain the largest contributor to deteriorating ozone and PM air quality in East Asia during the study period, but the climate change and land cover changes could lead to a substantial modification of ozone and PM levels.

S3C-6

Synoptic weather patterns of springtime high PM10 and yellow dust events in Seoul, South Korea

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The synoptic weather patterns of springtime (March to May) high PM10 and yellow dust events in Seoul, South Korea, are examined for the period of 2001-2014. The high PM10 events are defined when the daily-mean PM10 concentration is greater than 100 μ g m-3 but well separated from the yellow dust events reported by the Korean Meteorological Administration. Although these events are highly polluted events as in the yellow dust events, they have very different synoptic characteristics from the yellow dust events. The high PM10 events, which are partly caused by local emissions, are typically associated with weak surface weather systems and characterized by positive geopotential height anomalies at 500 hPa over the Korean peninsula. The self-organizing map (SOM) analyses reveal that these events are often influenced by multiple weather patterns. While some events accompany strong low-level southwesterly, possibly indicating regional PM10 transport from the eastern China, other events show a stagnant pattern that enhances an accumulation of local PM10 emissions. In contrast, yellow dust events, which are originated from the northern Chinese deserts, are accompanied by well-defined synoptic-scale cyclones that travel eastward from the northern China to the Manchuria. These cyclones are baroclinically well organized and effectively transport desert dusts to the Korean peninsula. On a central date, the synoptic pattern at 500 hPa is characterized by negative geopotential height anomalies over the Korean peninsula in stark contrast to those during the PM10 events.