Short-lived climate pollutant issues in the mitigation of the global warming

*中島 映至[1]、大原 利眞[2]、増井 利彦[2]、竹村 俊彦[3]、芳村 圭[4]、五藤 大輔[2]、鈴木 健太郎[4]、S-12 サイエンスチーム
*Teruyuki Nakajima[1], Toshimasa Ohara[2], Toshihiko Masui[2], Toshihiko Takemura[3], Kei Yoshimura[4], Daisuke Goto[2], Kentaroh Suzuki[4], S-12 Science Team

1. 宇宙航空研究開発機構　地球観測研究センター、2. 国立環境研究所、3. 九州大学応用力学研究所、4. 東京大学大気海洋研究所
1. EORC, Japan Aerospace Exploration Agency, 2. National Institute for Environmental Studies, 3. RIAM, Kyushu University, 4. Atmosphere and Ocean Research Institute (AORI), The University of Tokyo

The Paris agreement, adopted in the UNFCCC COP21 round, set the 2 degrees target and 1.5 degrees effort of global warming after the industrial revolution. These targets mean that the society has to pay significant efforts to reduce the long-lived greenhouse gases (LLGHGs) emission. Another problem is that the notable reduction of the surface temperature does not appear in the next two decades even with a substantial reduction of LLGHGs, because of the long lifetime of the LLGHGs. As one of other mitigation methods, a concept of the short-lived climate pollutants (SLCP), which include black carbon (BC) aerosols, tropospheric ozone, and methane, has been introduced by UNEP. According to the UNEP report for black carbon and tropospheric ozone, it will be possible to reduce the global surface temperature of about 0.5 degrees in a short period after substantial removal of SLCP emission. There are several mitigation initiatives along this idea, such as the UNEP Climate and Clean Air Coalition (CCAC), has been launched.
It is, however, there are several recent studies that the SLCP impact on the global surface temperature is not large, so that a careful analysis of the SLCP impact has to be made. We like to discuss this issue in this talk based on several past studies and results of the ERTDF S-12 project. Important subjects of the analysis are links between 1) air quality and SLCP emissions, 2) emission and mitigation technologies, and 3) SLCP concentration and the earth's climate change.

キーワード：地球温暖化、短寿命気候汚染物質、UNFCCC
Keywords: global warming, short-lived climate pollutants, UNFCCC

Effects of snow-darkening by absorbing aerosols on early spring snow melt and summer heat waves over Eurasia.

*William K-M Lau[1], Kyu-Myong Kim[2], Jeong Sang[3], Maeng-Ki Kim[3], T. J. Yasunari[4], Randal Koster[2]

1. University of Maryland College Park, 2. NASA/Goddard Space Flight Center, 3. Kongju University, 4. Hokkaido University

Using the NASA GEOS-5 Earth System Model, we have carried out a series of 10 x10 years ensemble experiments to explore the impacts of snow-darkening effect (SDE), *i.e.,* surface albedo reduction due to deposition of absorbing aerosols (BC and OC) and dusts on the surface energy and water balance, and on extreme heat waves over Eurasia. Comparing the model climate with SDE to a control climate without SDE, we find that a) desert dust contributes the strongest SDE over eastern Europe/Western Asia region, while BC has maximum SDE over southwestern Europe, and northern East Asia, b) over the above areas, the maximum surface warming induced by SDE is 3–5°C near the snowline, during the spring melting season, c) ground wetness increases due to accelerated snowmelt during early to late spring, but subsequently decreases due to enhanced evaporation as land warms, and more exposure of bare land areas, as the snowmelt accelerates, and d) following the retreat of the snowline, the maximum surface warming migrates to northern Eurasia, while the continental land region continues to dry up through the following summer.

The continued drying of land and surface warming over Eurasia reduce tropospheric humidity, and suppresses cloud formation, leading to atmospheric blocking conditions, with increased geopotential height and anomalous anticyclonic circulation over Eurasia. The aforementioned sequence of SDE induced changes in water and energy cycles, and associated land-atmosphere interactions from boreal spring through summer eventually lead to a doubling of the frequency of top 10% hot days, and 10-fold increase in the frequency of the top 1% hot days in the summer months over western and northern Eurasia. Impacts of snow-darkening effect of Himalayan snowpack on the Asian summer monsoon will also be discussed.

Keywords: absorbing aerosols, snow-darkening effects, early snow melt and summer heat waves over Eurasia

Seasonal and interannual variation in aerosol outflow from Asia/China and its controlling factors

*須藤 健悟[1,2]、山下 剛史[1]
*Kengo Sudo[1,2], Tsuyoshi Yamashita[1]

1. 名古屋大学大学院環境学研究科地球環境科学専攻、2. 海洋研究開発機構
1. Graduate School of Environmental Studies, Nagoya University, 2. Japan Agency for Marine-Earth Science and Technology

This study reveals seasonal and interannual variability in aerosol outflow from Asia and China (as the major source regions) and its controlling factors using simulations with a global chemical climate model. In the simulations, anthropogenic emissions are kept constant at the 2008 level to easily detect effects of meteorological variation. The model simulations are validated with the satellite observations of aerosol optical depth (AOD) and column burden of carbon monoxide (CO). The distributions and seasonal variations of simulated AOD both show a good agreement with satellite observations over maritime regions, while the model overestimates AOD over China in winter. On the other hand, simulated burden of CO is largely consistent with the satellite observations in the Asian regions including China.
This study also reveals the regional budgets of aerosols within Asia and China, focusing on black carbon (BC), organic carbon (OC) and sulfur oxides (SOx; SO_2 and sulfate) as aerosol components. Basically, zonal flux of aerosol is much larger than meridional one. Aerosol outflow across the east boundary of the China region, which shows significant large aerosol fluxes in 30°N-45°N, and the inflow across the west boundary of it both peak in March regardless of components of aerosols. In terms of interannual variation of aerosol outflow, the year to year change of zonal flux plays central role in total variability of aerosol outflow. Of the emitted BC, OC, and SOx from China, about 38%, 20%, and 25% are fractionally exported outside of the region, respectively. The simulated aerosol outflow is validated with diagnosis based on the satellite observation of AOD following the method by Yu et al. (2008). The simulated aerosol outflow across the boundary at the eastern edge of China agrees well with the outflow derived from the satellite observation for both quantitative level and seasonal to interannual variations. The aerosol outflow derived by this study shows a positive trend of 1-2% per year for the period of 2000-2015, which suggests increasing anthropogenic emissions in East Asia during the recent decades.
In addition, to interpret interannual variability in regional aerosol burden over Asia and China, its controlling mechanism is separated into three independent factors of emission, deposition, and export outside the region using a multiple regression analysis for total aerosol burden. The result shows that burden variation of BC in Asia and China is principally controlled by export outside the region, whereas SOx variation is by regional deposition; to OC variation, export and regional deposition equally contribute. Therefore, the BC outflow from China can affect climate and atmospheric environment in both local and remote areas.
Furthermore, to assess the aerosol effects on climate and air quality in downwind region, this study investigates controlling factors of interannual variations of aerosol outflow from China. By a composite analysis for winter, it is shown that in the phase of relatively enhanced aerosol outflow from China, a dipole-like anomaly presents exhibiting negative/positive deviation in interior of China and its downwind regions including India and Southeast Asia, respectively. It is also suggested that aerosol outflow from China has a negative correlation with the strength of Asian monsoon. Accordingly, modulation of Asian monsoon associated with climate change can cause additional climate effects through varying aerosol outflow from the polluted area.

キーワード：エアロゾル、長距離輸送、アジアモンスーン、化学輸送モデル、化学気候モデル
Keywords: aerosol, long-range transport, Asian Monsoon, Chemical Transport Model, Chemistry Climate Model

Winter monsoon variability and its impact on aerosol concentrations in East Asia

*Rokjin Park[1], Jaein Jeong[1]

1. Seoul National University

Monsoons play a key role in synoptic weather patterns, which affect the frequency and longevity of pollution events. In East Asia, particulate matter (PM) pollution is particularly severe in winter. In this study, we investigate the relationship between winter aerosol concentrations and the East Asian Winter Monsoon (EAWM) variability using a global 3-D chemical transport model (GEOS-Chem) and ground PM observations. A strong relationship between aerosol concentrations and the intensity of the EAWM is found, but shows a different sign for northern and southern East Asia. Compared to the climatological mean aerosol concentrations in winter, changes driven by the EAWM variability are up to 25% in East Asia in the model. The EAWM variability is found to play a major role in interannual variations in aerosol concentrations; consequently, changes in the EAWM will be important for understanding future changes in wintertime PM air quality in East Asia.

Keywords: Aerosol, Winter monsoon, East Asia

Satellite-based diagnostics of aerosol-cloud-precipitation-radiation interactions within a cloud regime framework

*Lazaros Oreopoulos[1], Nayeong Cho[2,1], Dongmin Lee[3,1]

1. NASA Goddard Space Flight Center, 2. University Space Research Association, 3. Morgan State University

Coincident multi-year measurements of aerosol, cloud, precipitation and radiation at near-global scales are analyzed to diagnose whether their apparent relationships are consistent with well-established paradigms. Specifically, we examine whether differences in aerosol loading in separate observations produce consistently different precipitation, cloud properties, and cloud radiative effects. Our analysis uses a cloud regime (CR) framework to dissect and sort the results. The source of the aerosol and CR information is the MODIS sensor, radiation iformation comes from CERES, while precipitation rates come from the TMPA-3B42 dataset. Our presentation will demonstrate that when global cloudiness is partitioned by cloud regime, apparent relationships emerge in many instances, and when they do, they can sometimes be clear and unambiguous, although they can differ between land and ocean. At the same time, there are numerous examples where the relationships are less straightforward and contrary to standard paradigms or prior modeling results and this was particularly the case for cloud regimes that contain ice and mixed phase clouds. These regimes are the most substantial precipitation producers, yet we were unable to find meaningful precipitation responses to aerosol. Radiative signatures for these clouds indicate greater cloud radiative effects with more aerosol loading. Results were clearer for liquid regimes and largely consistent with 1st and 2nd indirect effect predictions, but no precipitation suppression could be discerned. Our most populous cloud regime of low cloud fraction exhibited in most cases dramatic apparent responses to AOD with unambiguous increases in precipitation, cloud extent, cloud optical thickness, cloud top height, and radiative effect accompanying AOD increases. I will discuss why our rather ambitious near-global analysis confirmed once again that finding robust evidence of aerosol effects on clouds and precipitation from observations is a very challenging endeavor.

Keywords: Cloud regimes, Cloud Indirect effect, Cloud Invigoration, Precipitation, Aerosol, Satellites

Assessment on the Atmospheric Impacts of Surrounding Fire Emissions: An Analysis on Malaysian Haze Episodes by Utilizing the Remote Sensing Satellite Information and Ground-Based Measurements

*Nur Atiqah Aainaa Abd[1], Machimura Takashi[1]

1. Division of Sustainable Energy and Environmental Engineering,Graduate School of Engineering,Osaka University

The recurrence of forest fires in Southeast Asia and associated biomass burning, has contributed significantly to the problem of intense haze and the long-range movement of pollutants in the Malaysian region. Air pollutants, specifically particulate matter in the atmosphere, have received extensive attention, mainly because of their adverse effect on people’ s health. However, the haze episodes coincided temporally with the occurrence of hotspots detected at the surrounding area such as in Sumatra and Kalimantan, Indonesia. In this study, the spatial and temporal variability of the PM10 concentration over Malaysia were analyzed by utilizing the satellite remote sensing information, air quality dataset and meteorological condition associated with this episodes. This study objective is to provide an assessment on the effects of surrounding forest fire events on the Malaysian haze. In this study, severe haze episodes during 2000 until 2013 were reviewed. The nature of the haze episodes, their possible causes and their major features were discussed in this paper. In order to analyze and detect the occurrence of active fires in surrounding region, MODIS Active Fire Data was retrieved from NASA/LANCE –FIRMS while the air quality data across Malaysia was assessed based on PM10 concentration which provided by Malaysian Department of Environment (MDOE). The meteorological database including temperature, rainfall, and wind speed were gathered from NOAA’ s National Climatic Data Center (NCDC). The results of this study indicates most of the intense haze episode in Malaysia were caused by the transboundary pollution from Sumatra and Kalimantan area which brought substantial amounts of particulate matter into the Malaysian atmosphere.

Keywords: Malaysia , Haze, PM10, Forest fire

Increases in wintertime aerosol concentrations and severe haze days in eastern China over the past decades: Roles of variations in meteorological parameters and anthropogenic emissions

*Hong Liao[1], Yang Yang[2], Ke Li[3]

1. School of Environmental Science and Engineering, Nanjing University of Information Science and Technology, Nanjing, China , 2. Atmospheric Science and Global Change Division, Pacific Northwest National Laboratory, Richland, Washington, USA, 3. Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China

The increases in wintertime aerosol concentrations and severe haze days in eastern China over the past decades were quantified by using observed atmospheric visibility, observed $PM_{2.5}$ concentrations, simulated $PM_{2.5}$ concentrations from the Goddard Earth-Observing System (GEOS) chemical transport model (GEOS-Chem), as well as simulated climate change from 15 CMIP5 climate models. Observed winter haze days (defined as days with atmospheric visibility less than 10 km and relative humidity less than 80%) averaged over eastern China (105–122.5˚E, 20–45˚N) increased from 21 days in 1980 to 42 days in 2014. Averaged over eastern China, simulated wintertime surface-layer $PM_{2.5}$ concentrations from the GEOS-Chem model exhibited an increasing trend of 10.5 (±6.2) $\mu g\ m^{-3}$ $decade^{-1}$ over eastern China in the past decades, in which the changes in anthropogenic emissions and in climate contributed 87% and 17%, respectively. Observed severe haze days (defined as days with observed $PM_{2.5}$ >150 $\mu g\ m^{-3}$) occurred mainly over Northern China. Conducive weather conditions, such as reduced surface winter northerlies, weakened northwesterlies in the midtroposphere, and enhanced thermal stability of the lower atmosphere, were an important ingredient of severe haze episodes. Results from the 15 CMIP5 models showed that the frequency of weather conditions conducive to severe haze events in northern China increased substantially under greenhouse warming.

Keywords: air quality, aerosol, climate change, severe haze, eastern China

Global simulations of tagged black carbon aerosols: Implications for Asian emissions and long-range transport to the Arctic

*谷本 浩志[1]、池田 恒平[1]、岡本 祥子[1]、金谷 有剛[2]、朱 春茂[2]、竹谷 文一[2]、杉田 考史[1]、秋吉 英治[1]
*Hiroshi Tanimoto[1], Kohei Ikeda[1], Sachiko Okamoto[1], Yugo Kanaya[2], Chunmao Zhu[2], Fumikazu Taketani[2], Takafumi Sugita[1], Hideharu Akiyoshi[1]

1. 国立環境研究所、2. 海洋研究開発機構
1. National Institute for Environmental Studies, 2. Japan Agency for Marine-Earth Science and Technology

Black carbon aerosols have substantial impacts on air quality and climate from regional to global scales. In the present study we implemented a tag-tracer scheme of black carbon (BC) into a global chemistry-transport model GEOS-Chem, and examined long-range transport of BC from various sources to the Arctic and quantified the source contributions. We distinguished BC tracers by source types (anthropogenic and biomass burning) and regions; the global domain was divided into 16 and 27 regions for anthropogenic and biomass burning emissions, respectively. Our simulation showed that BC originating from Europe and Russia is transported to the Arctic mainly in the lower troposphere during winter and spring. In particular, BC transported from Russia extensively distributed over the Arctic in winter and spring, leading to the dominant contribution of 62 % to the Arctic BC near the surface in annual mean. In the middle troposphere, BC from East Asia is transported to the Arctic mainly through Okhotsk Sea and East Siberia during winter and spring. We identified important region where a strong inflow from East Asia to the Arctic occurs (130–180˚E and 4–7 km altitude at 66˚N). The model demonstrated that the contribution from East Asia to the Arctic shows a maximum at about 5 km altitude due to the uplifting during the long-range transport in early spring. The efficiency of transport from East Asia to the Arctic is smaller than the other large source regions such as Europe, Russia and North America. However, the contribution of East Asia is most important to the middle troposphere (41 %) and BC burden (27 %) over the Arctic because of the large emission from this region. These results suggest that the main sources of the Arctic BC are different with altitude. The total contribution of anthropogenic sources to BC concentrations near the surface is dominant compared with that of biomass burning in annual mean. However, for total deposition of BC on the Arctic, the contributions of biomass burning from Siberia and Alaska and Canada that become large only during summer were estimated to be 15 % and 12 %, respectively.

キーワード：ブラックカーボン、北極、化学輸送モデル
Keywords: black carbon, Arctic, chemistry-transport model

Overview of the studies of SOA in fogwater and proposal of field observational research in Asia

*Hajime Akimoto[1]

1. National Institute for Environmental Studies

It has been well known that reactions of carbonyl compounds in fogwater are important sources of secondary organic aerosols (SOA) in the atmosphere (Ervens et al., 2013). Specifically, dicarboxylic acids, organosulfates, organonitrates, and imidazoles are water-soluble chemical species are expected to be formed in cloud/fog water. Although fog water chemistry was historically focused on inorganic species such as SO_4^{2-}, NO_3^-, NH_4^+, Ca^{2+}, etc. related to acid deposition, recent interest has been directed toward organic species related to air quality and climate change. In this paper, field observations of organic species in fogwater are briefly reviewed trying to identify and quantify the importance of cloud/fog chemistry for aerosols formation.
Fog and ground based cloud sampling and analysis of organic compounds have been rather intensively performed in United States and Europe with a very limited occasion in Asia (Herckes et al., 2013). In most of these studies, the analyses have been made only for organic carbon mass (OC) rather than chemical species. For the evaluation of the importance of fog chemistry in aerosol formation, identification of organic compounds with high-resolution mass spectrometry (for example Mazzoleni et al., 2010) or other sophisticated instruments are definitely needed.
On the other hand, haze pollution is very serious in many cities in Asia, and it has been well known that they contain very high concentrations of SO_4^{2-}, NO_3^-, and NH_4^+, as well as organic aerosols. The concentrations of reactive carbonyl compounds and inorganic ions in fogwater are expected to be comparable in many areas in Asia. Thus, the formation of organic sulfates and organic nitrogen compounds would be much facilitated, and their concentrations in fogwater may be much higher than in US and Europe.
Field observational research to analyze organic chemical species in fogwater and aerosols simultaneously to quantify the importance of atmospheric aqueous phase reactions would be significant both for understanding fundamental science and quantification of $PM_{2.5}$ for air quality.

References

Ervens D. E. et al., Dissolved organic carbon (DOC) and select aldehydes in cloud and fog water: the role of the aqueous phase in impacting trace gas budgets, Atmos. Chem. Phys., 13, 5117–5135, 2013.
Herckes, P., K. T. Valsaraj, and J. L. Collett Jr., A review of observations of organic matter in fogs and clouds: Origin, processing and fate, Atmos. Res., 132–133, 434–449, 2013.
Mazzoleni L. R. et al., Water-soluble atmospheric organic matter in fog: exact masses and chemical formula identification by ultrahigh-resolution Fourier transform ion cyclotron resonance mass spectrometry, Environ. Sci. Technol., , 44, 3690–3697, 2010.

Keywords: SOA, Fogwater

Primary Biological and Biomass Burning Aerosols at the Northern Slope of Mt. Everest, Central Himalayas

*Pingqing Fu[1], Zhiyuan Cong[2], Kimitaka Kawamura[3]

1. Insititute of Atmospheric Physics, Chinese Academy of Sciences, Beijing 100029, China, 2. Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100085, China, 3. Chubu Institute for Advanced Studies, Chubu University, Kasugai, Japan

Organic aerosols from biomass burning and primary biological sources are ubiquitous in the Earth’s atmosphere. They affect the absorption and scattering of solar radiation, act as cloud condensation nuclei (CCN) and possibly influence ice and snow albedo in remote regions. Here we determined polar organic markers for biomass burning, plant debris and primary biological aerosols at a remote site (Qomolangma, 4276 m a.s.l.) of Mt. Everest, central Himalayas using a solvent extraction-BSTFA derivatization-GC/MS technique. Seasonal trends of biomass-burning aerosols are characterized by pronounced maxima in the pre-monsoon season and minima in the summer monsoon period, being consistent with aerosol organic carbon. However, concentrations of fungal spore tracers and pland debris peaked in both pre-monsoon and post-monsoon seasons, suggesting that primary bioaerosols and plant emission are important sources of organic aerosols over the Tibetan Plateau in the post-monsoon season when biomass burning emission is weak. With the consideration of primary bioaerosol particles as pontetial CCN and atmospheric ice nuclei and biomass burning as one of the significant sources of light-absorbing aerosols, our findings have potential implication for climate change in the Tibetan Plateau, a major concern in the Earth’s “Third Pole”.

Keywords: Biomass burning, Primary biological aerosols, The Tibetan Plateau, Secondary organic aerosols

A study of the 2016 post-monsoon air pollution event over India using the GMAO GEOS system

*Anton Darmenov[1], Jon Nielsen[3], Christoph Keller[2], Katherine Knowland[2]

1. NASA Goddard Space Flight Center, 2. GESTAR, 3. SSAI

The countries in South Asia are particularly vulnerable to air pollution. With population of over 1.3 billion people (and high population density) India for example can be severely impacted by air pollution episodes amplified by the combination of the regional topography and winds, abundant natural aerosols and increased industrial growth and urbanization. In October-November 2016 a large scale pollution event that coincided with the post-monsoon burning of crop residue was observed from space over India. Predominantly clear sky conditions allowed the MODIS and CALIPSO instruments on board of NASA EOS satellites to reveal the scale and the duration of length of this air pollution episode and make aerosol retrievals. Characterization of the air pollution and the impact on the air quality and population was however impeded by the sparse PM and other air-pollutants observations.

The goal of this study was to analyze the post-monsoon air pollution episode by using observations from NASA satellites in conjunction with the GMAO GEOS system with emphasis on near real-time analysis and short term prediction capabilities. We examined and identified the major causes that lead and contributed to this event. Our analysis showed a clear link between the agricultural fires and the air pollution levels in India. In addition, we assessed the population affected by unhealthy pollution levels by using the air quality index derived from the standard model output.

Keywords: GEOS, aerosols, air quality

Impact of biomass burning emissions on atmospheric aerosol burdens over the Sao Paulo Metropolitan Area

*Angel Liduvino Vara Vela[1], Maria de Fatima Andrade[1], Yang Zhang[2], Prashant Kumar[3], Rita Ynoue[1]

1. Sao Paulo Univ., 2. North Carolina State Univ., 3. Surrey Univ.

Since the gases and particles ejected into the atmosphere from fire emission events can modify the atmospheric composition around and even far away from the sources, an accurate representation of fire emissions in atmospheric chemical transport models is very important to improve the current understanding on how these emissions impact the aerosol properties over urban areas. In this study, the Weather Research and Forecasting with Chemistry (WRF-Chem) model, a state-of-the-art coupled meteorology-chemistry modelling system, is used to describe the physicochemical processes involving the emission, formation and transport of gases and aerosols in order to characterise the main properties of atmospheric aerosol particles over the Sao Paulo Metropolitan Area (SPMA), in southern Brazil, focusing mainly on the impact of biomass burning source. The study period of August 19 –September 3, 2014 is selected due to the occurrence of biomass burning of agricultural residues and high values of pollutants concentration in SPMA. To evaluate the impact of biomass burning it is considered the experimental data collected during the last campaign from the Narrowing the Uncertainties on Aerosol and Climate Change in Sao Paulo State (NUANCE-SPS) project and a set of two 18-day WRF-Chem simulations including different emission settings: with (BASE) and without (NFE) fire emissions. Ground-based aerosol observations from NUANCE-SPS include mass and number size distribution and CCN, elemental carbon (EC), and $PM_{2.5}$ ($PM_{2.5}$; 2.5 μm in diameter) and PM_{10} (PM_{10}; 10 μm in diameter) concentrations. In addition, lidar profiles complemented with satellite observations are used to assess aerosol optical properties. Despite the meteorological conditions during most of the period were not favourable for long-range transport into SPMA, comparisons of the two simulations BASE and NFE with observations show that the inclusion of fire emissions can raise the concentration of fine particles by up to 8 ug/m^3 which in turn reduces the bias hence improving the model performance. Lower predicted $PM_{2.5}$ concentrations are mainly related to underestimates on the calculation of emissions as well as the SOA concentration.

Keywords: biomass burning emissions, atmospheric aerosols, WRF-Chem model

The solar absorptivity of organic carbon and its impact on Asian summer monsoon

*Jung-Eun Chu[1,2], Kyung-Ja Ha[1,3], Kyu-Myong Kim[4]

1. Pusan Nat'l Univ., 2. ICCP, 3. RCCS, 4. NASA GSFC

Light absorbing aerosols not only contribute to Earth’s radiative balance but also influence regional climate by cooling the surface and warming the atmosphere. Despite growing evidence of light-absorbing organic aerosols (OAs), their contribution to the Earth’s radiative budget is still poorly understood. In this presentation, we will show an evidence of solar absorption of OA and its impact on Asian summer monsoon. In the first part, we derive an algorithm that empirically determine OA solar absorptivity in terms of single-scattering albedo (SSA) mostly using the ground-based Aerosol Robotic Network (AERONET) observation over biomass burning regions. Our best estimate of OA SSA over the tropical biomass burning regions is 0.91 at 550 nm. The results imply that most aerosol models as well as climate models, which commonly use OA SSA of 0.96–1.0, have so far ignored light absorption by OAs. In the second part, we examine the role of light absorbing properties of OA on Asian summer monsoon rainfall redistribution using observational data and an atmospheric general circulation model (AGCM) experiment. Both observation and the model experiment suggest that the enhanced light absorption by OA in Southeast Asia and Northeast Asia are associated with the advance of the Indian summer monsoon in May and the southward shift of East Asian summer monsoon rainband in June. We further find that the rainfall redistribution of the Indian summer monsoon is induced by a so-called “elevated heat pump (EHP) effect” with formation of a warm-core upper-level anticyclone and surface warming of 1-2°C over the Tibetan Plateau whereas that of the East Asian summer monsoon is formed by stable conditions associated with surface cooling and atmospheric warming around 30°N.

Keywords: Organic aerosol light absorption, light absorbing aerosol, Asian summer monsoon and aerosol interaction

Carbonaceous Aerosols: a View from GLI's near-UV Data

*Alexei Lyapustin[1]

1. NASA Goddard Space Flight Center

Global Land Imager (GLI) onboard of ADEOS !! platform provided about 9 months of data in 2003. GLI design was remarkably close to MODIS, but also contained two additional shortwave channels at 400 nm and 388nm. Within NASA GeoCAPE project, we have adapted the Multi-Angle Implementation of Atmospheric Correction (MAIAC) algorithm for GLI processing, and enhanced it to derive aerosol spectral absorption information from 400nm and 388nm bands. The aerosol retrievals are performed at high 1km resolution which gives a unique picture of dynamic evolution of carbonaceous aerosols from the centers of fires. We will show different examples of fresh smoke as well as aged/transported smoke bringing insights into black/brown carbon dynamics.

Keywords: aerosol, brown carbon

NASA/GSFC SMARTLabs Mobile Facility: Probing air quality and aerosol-cloud effects on the environment

*Si-Chee Tsay[1]

1. NASA Goddard Space Flight Center

Air quality, as a measure of natural and anthropogenic emissions of pollutants (particulate matter and trace gases) into the atmosphere, is receiving increasing global attention. It correlates with the health of humans and ecosystems and is also a reflector of meteorological processes occurring predominantly on local to regional scales. In support of the NASA Earth Observing System (EOS) and future Decadal Survey endeavor, GSFC's mobile SMARTLabs (Surface-based Mobile Atmospheric Research & Testbed Laboratories; *cf.* http://smartlabs.gsfc.nasa.gov/) were conceptualized, built and have participated in numerous field campaigns. The overarching goal of the SMARTLabs mobile facility is to enrich NASA Earth Sciences by (1) contributing to NASA satellite missions in providing calibration/validation of data products, (2) piloting innovative science research through the mobility, flexibility and rich suite of complementary instruments offered in these test-bed platforms, and (3) promoting NASA Earth Sciences through educational and public outreach activities.

The sizes of atmospheric constituents vary by several orders of magnitude (e.g., *gas molecules on the order of* 10^{-10} *m to solid hydrometeors of* 10^{-2} *m)* and their compositions, from simple substances to complex compounds. SMARTLabs integrates a unique suite of remote sensing and *in-situ* instruments for observing the properties of atmospheric components including clouds, aerosols, and precursor species. Two different kinds of data products arising from SMARTLabs are those directly measured/retrieved (spectral optical thickness, *in-situ* properties near surface, etc.) and those derived from combining products (e.g., aerosol hygroscopic growth factors). These data products reflect advances in methods of observations and technological progresses in instrumentation. As model simulations inevitably become more detailed (reflecting increased understanding of atmospheric processes), they will use and rely increasingly on such data products and, as must be expected, will feedback new instrumental requirements and observational strategies. Indeed, such refinements have made possible predictive capabilities that describe how future changes in atmospheric composition affect air quality and climate. SMARTLabs measurements and data products are uniquely poised to address these challenges. Additionally, in light of the expected hiatus in satellite observations between the conclusion of EOS flagship and the Decadal Survey missions, the mobility, flexibility and rich suite of complementary instruments offered by SMARTLabs can be utilized to probe atmospheric phenomena of interest, thus providing a test-bed platform and a *partially* gap-filling measure. We will present, as an example, results from the 7-SEAS/BASELInE (Seven SouthEast Asian Studies/Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles & Interactions Experiment) conducted in spring 2013–2015 over northern Southeast Asia.

Keywords: Ground-based, Aerosol, Cloud

Carbonaceous Aerosols in Foggy Days During Episodic Fireworks Event

*Pallavi Saxena[1], Umesh Kulshrestha[1]

1. Jawaharlal Nehru Univ.

The present study deals with the variation of organic carbon (OC) and elemental carbon (EC) on foggy days during fireworks of Diwali festival in New Delhi. The samples were collected at different selected sites viz. JNU (dense vegetative), VN (residential) and AN (industrial) in Delhi, India. In this study, average OC and EC concentrations were found to be higher at VN i.e. 99.24 $\mu g/m^3$ and 24.31 $\mu g/m^3$ respectively as compared to AN (90.93 and 19.85 $\mu g/m^3$ respectively) and JNU (19.59 and 5.55 $\mu g/m^3$ respectively) indicating more influence of burning of fireworks during Diwali and also relatively dense populated area which favours more vehicle density as compared to rest of the sites. EC concentrations were found to be OC/EC ratios found to be 2.69, 3.85 and 4.16 in case of Pre-Diwali days, 3.30, 4.06 and 4.80 in case of Diwali and 2.33, 3.87 and 4.21 in case of Post Diwali days respectively at sites JNU, VN and AN. These ratios clearly indicate that during sampling period (covering in and around Diwali) at VN and AN sites, sufficient formation of SOA is favoured. Another reason can be, the sampling period month is November which is pre-existing winter month that involves wood burning and ultimately increase emission of volatile secondary organic compounds which condensed to form aerosols under low temperature. In addition to that, fog is also a triggering factor which occurs during winter and recorded in all days of sampling period that would increase the SOA formation and favours gas-to-particle conversion mechanisms and ultimately adsorb gaseous pollutants. Another interesting finding is that high concentrations of OC and EC were found during Diwali period but gradually declined during Post Diwali periods at all the sites. High amount of charcoal used in crackers might be the reason for high EC especially during Diwali day, but, gradually the concentrations of carbonaceous aerosols goes down during Post Diwali period because fog is a factor which act as scavenger and during Diwali, fog was observed but it doesn't affect the chemistry of carbonaceous aerosols because fresh emission from local sources like firework activities, are generally less hydrophilic, but after 2-3 days of fresh emissions, these particles become aged particles and fog can scavenge them and gradually long-lived species would give rise to the formation of SOA. In comparison to OC, EC has relatively shown less decline because due to thick coatings and less soluble properties, it scavenge less as compared to OC. Hence, fog play a significant role as a scavenger which can reduce the concentration of OC and EC with respect to freshly emitted and aged particles.

Keywords: OC, EC, Fireworks, Foggy Days, Delhi, Diwali

Understanding the efficacy leading to high concentration of PM2.5 in a changing climate

Understanding the efficacy leading to high concentration of PM2.5 in a changing climate

*Yeh Sang-Wook[1]、Lee Jong-Won[1]、Kim Minjoong[2]、Park Rokjin[2]
*Sang-Wook Yeh[1], Jong-Won Lee[1], Minjoong Kim[2], Rokjin Park[2]

1. Hanyang University、2. Seoul National University
1. Hanyang University, 2. Seoul National University

We investigate the efficacy leading to high concentration of PM2.5 in a changing climate. To obtain the meteorological variables to the global chemical transport model (GEOS-Chem), we first conduct the historical run (1996-2005) and the four RCP runs (RCP2.6, RCP4.5, RCP6.0 and RCP8.5) in the two periods, 2016-2025 and 2046-2055, using the Community Earth System Model (CESM). With the same emission dataset used in the CESM, the GEOS-Chem assimilated by the meteorological variables from the CESM simulates produces a number of aerosol species in the present climate and future climate. We pay attention to the changes in the PM2.5 concentration simulated by the GEOS-Chem from the present climate (1996-2005) to the future climate (2016-2025 and 2046-2055). It is found that the PM2.5 concentration in the future climate is largely regulated by the emission scenario. Therefore, it is crucial to correctly know the emission scenario to predict the PM2.5 concentration in future climate. And then, we analyze the ratio of emission and concentration of PM2.5 in the present climate and future climate to examine the efficacy leading to high concentration of PM2.5. It is found that the efficacy increases in different RCP scenarios in each period (2016-2025 and 2046-2055) when the La Nina-like SST cooling occurs. The atmospheric conditions associated with a La Nina-like SST cooling provides more favorable condition to increase the efficacy leading to high concentration of PM2.5 in East Asia. We also compared with the two periods (2016-2025 and 2046-2055) in the four RCP scenarios in terms of the efficacy leading to high concentration of PM2.5 and we found that the efficacy for 2046-2055 is higher than that for 2016-2025 in spite of a reduction of emission.

キーワード：PM2.5、emission、La Nina-like SST
Keywords: PM2.5, emission, La Nina-like SST

The top and bottom 10 monthly light-absorbing aerosol deposition anomalies over the Greenland ice sheet during 2003-2016 and their corresponding changes in atmospheric aerosol pattern

*安成 哲平[1]、Kim Kyu-Myong[2]、da Silva Arlindo[2]
*Teppei J Yasunari[1], Kyu-Myong Kim[2], Arlindo da Silva[2]

1. 北海道大学　大学院工学研究院、2. NASA Goddard Space Flight Center
1. Faculty of Engineering, Hokkaido University, 2. NASA Goddard Space Flight Center

Nowadays, the melting of the Greenland ice sheets (GrIS) along the ongoing climate change is one of large concerns for many people. It is well known from previous studies (e.g., Qian et al., 2015, and references therein; Yasunari et al., 2015) that the snow-darkening by deposited light-absorbing aerosols (i.e., LAA: dust, black carbon, and organic carbon) is one of the factors for accelerating melting. In this presentation, we examine the top and bottom 10 monthly LAA deposition flux anomalies over GrIS during 2003-2016 and associated changes in atmospheric circulations and LAA loading patterns, using the NASA’s MERRA-2 re-analysis data (Bosilovich et al., 2015; Randles et al., 2016).

Here we define the areas for the LAA deposition anomalies over GrIS as the grid points where the monthly mean snow mass (i.e., snow water equivalent, SWE) over glaciated surface is greater than 500 kg m^{-2} within a domain including GrIS (287˚E-339˚E; 59˚N-85˚N). The monthly LAA deposition flux anomalies were calculated from the their monthly climatologies for 2003-2016. Then, we selected the top and bottom 10 months of dust, BC, and OC deposition flux anomalies for higher and lower cases of the LAA depositions over GrIS, respectively. To discuss the atmospheric LAA conditions for the higher and lower LAA deposition time periods, we also used column mass densities of dust, BC, and OC and calculated the composites of their column mass densities for the top and bottom 10 LAA deposition months. The differences of the composites for each LAA component can tell us the possible LAA source information which could contribute to generate higher LAA deposition flux anomalies over GrIS during 2003-2016.

For dust, higher atmospheric dust amount changes over Middle East and North Africa were seen for the composite difference of the column mass density of dust between the cases of the top and bottom 10 dust deposition anomalies over GrIS. This implies that these two sources could mainly contribute to make the higher dust deposition months over GrIS during 2003-2016. For OC, some hot spots were seen over the eastern part of the Lake Baikal, Eastern Siberia, and Canada. Probably smokes from biomass burnings over these areas significantly had responsibilities to highly increase OC depositions over GrIS. For BC, although increased BC column mass densities were seen over Eastern Siberia and Canada as were seen for the OC case, broadly increased BC were also seen over Alaska, the Indo-Gangetic Plains, South East Asia, and Central Africa. This implies that the source attributions of higher BC deposition months over GrIS are more complicated, compared to dust and OC source attributions.

References

Bosilovich, M. G., et al. (2015), MERRA-2: Initial Evaluation of the Climate, *NASA Technical Report Series on Global Modeling and Data Assimilation*, NASA/TM–2015–104606, 43, 139 pp. (available at: https://gmao.gsfc.nasa.gov/pubs/docs/Bosilovich803.pdf).

Qian, Y., T. J. Yasunari, S. J. Doherty, M. G. Flanner, W. K. M. Lau, J. Ming, H. Wang, M. Wang, S. G. Warren,

and R. Zhang (2015), Light-absorbing particles in snow and ice: measurement and modeling of climatic and hydrological impact, *Adv. Atmos. Sci.*, 32(1), 64-91, doi: 10.1007/s00376-014-0010-0.

Randles, C. A., et al. (2016), The MERRA-2 Aerosol Assimilation, *NASA Technical Report Series on Global Modeling and Data Assimilation*, NASA/TM-2016-104606, 45, 143 pp. (available at: https://gmao.gsfc.nasa.gov/pubs/docs/Randles887.pdf).

Yasunari, T. J., R. D. Koster, W. K. M. Lau, and K.-M. Kim (2015), Impact of snow darkening via dust, black carbon, and organic carbon on boreal spring climate in the Earth system, *J. Geophys. Res. Atmos.*, 120, 5485–5503. doi: 10.1002/2014JD022977.

キーワード：グリーンランド、エアロゾル沈着、ダスト、ブラックカーボン、オーガニックカーボン、雪
Keywords: Greenland, aerosol depositions, dust, black carbon, organic carbon, snow

