Potential impact of snow darkening effect by light-absorbing aerosols on the hydrological cycle over Eurasia

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In this study, we present the possible impact of snow darkening effect (SDE) on the hydrological cycle over Eurasia by light-absorbing aerosols using the NASA GEOS-5 Model experiments with aerosol tracers and a state-of-the-art snow darkening module, Goddard SnoW Impurity Module (GOSWIM) for the land surface. Results show that SDE can have a significant regional dependency in partitioning the role of evaporative and advective components on the hydrological cycle, especially during spring and summer season. Over the western Eurasia (40-60˚N, 20-60˚E), SDE-induced rainfall increase during early spring can be largely explained by the increased evaporation from snowmelt. Rainfall, however, decreases in early summer due to the reduced evaporation as well as moisture divergence associated with the development of anticyclonic circulation. On the other hand, in the East Asian region, the moisture advection from adjacent ocean is a main contributor to rainfall increase in the melting season. Warmer land-surface due to earlier snowmelt further increases moisture convergence and significantly increases rainfall over the region. This finding suggests that the SDE may play an important role in advancing and strengthening monsoonal circulation in East Asia, while it may lead to dry and hot summer by intensifying blocking high over the mid-western Eurasia

Keywords: Snow darkening effect, Light-absorbing aerosol, Hydrological cycle, Asian summer monsoon, Heat wave

Impacts of snow darkening by absorbing aerosols on South Asian monsoon

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North-south temperature reversal caused by the seasonal heating over the Tibetan Plateau is a main driver of the onset of the South Asian Monsoon. Aerosols can play an important role in pre- and early monsoon seasonal heating process over the Tibetan Plateau by increasing atmospheric heating in the northern India, and by heating of the surface of the Tibetan Plateau and Himalayan slopes, via reduction of albedo of the snow surface through surface deposition –the so call snow-darkening effect (SDE). To examine the impact of SDE on weather and climate during late spring and early summer, two sets of NASA/GEOS-5 model simulations with and without SDE are conducted.

Results show that SDE-induced surface heating accelerates snow melts and increases surface temperature over 4K in the entire Tibetan Plateau regions during summer. Warmer Tibetan Plateau further accelerates seasonal warming in the upper troposphere and increases the north-south temperature gradient between the Tibetan Plateau and the equatorial Indian Ocean. SDE-induced increase of the meridional temperature gradient drives meridional circulation and enhanced upper tropospheric easterlies and lower tropospheric westerlies, and intensifies monsoon circulation and rainfall. This pattern enhances the EHP-like circulation anomalies induced by atmospheric heating of absorbing aerosols over the northern India. The results suggest that SDE-induced early snow melting over the Tibetan Plateau may cause early and stronger monsoon in early summer.

Keywords: Aerosol, Snow darkening, Summer monsoon

JMA/MRI Aerosol Reanalysis Product

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A global aerosol reanalysis product covering the period 2011–2015 was constructed by the Meteorological Research Institute (MRI) of Japan Meteorological Agency (JMA). The reanalysis employs a global aerosol transport model developed by MRI (MASINGAR mk-2) and a 2-dimensional variational method, assimilates maps of aerosol optical depth (AOD) from the Moderate Resolution Imaging Spectroradiometer (MODIS) onboard Terra and Aqua satellites every 6 hour, and has horizontal resolution of TL159 (approximately 1.1˚× 1.1˚). In this presentation, we overview setup of the reanalysis as well as indication of its quality.
Comparing with the MODIS AOD shows that the reanalysis improved the under- and overestimates in the free run and exhibits much better agreement than the free run of the aerosol model confirming a sanity of the data assimilation system. The reanalysis obtains root mean square error (RMSE) = 0.05, correlation coefficient (R) = 0.96, mean fractional error (MFE) = 23.7%, mean fractional bias (MFB) = 2.8%, and index of agreement (IOA) = 0.98. The better agreement of the first guess comparing with the free run indicates that aerosol fields obtained by the reanalysis can improve the short-term forecasting.
AOD fields from the reanalysis agree well with monthly averaged AODs from the Aerosol Robotic Network (AERONET) with RMSE = 0.08, R = 0.90, MFE = 28.1%, MFB = 0.6% and IOA = 0.93 over the globe. Site-by-site comparison shows that the reanalysis is considerably better than the free run and achieves RMSE < 0.10, R > 0.90, and IOA > 0.90 at 86.4%, 40.7%, and 43.4% of the 181 AERONET sites, respectively. However, the reanalysis tends to have negative bias at urban sites (particularly megacities in industrializing countries) and positive bias at mountainous sites possibly due to insufficient anthropogenic emission, the coarse model resolution, and difference of representativeness between the satellite and ground-based observations.

Keywords: aerosol, reanalysis, data assimilation

Near-real-time aerosol forecast experiment with Himawari-8 aerosol product

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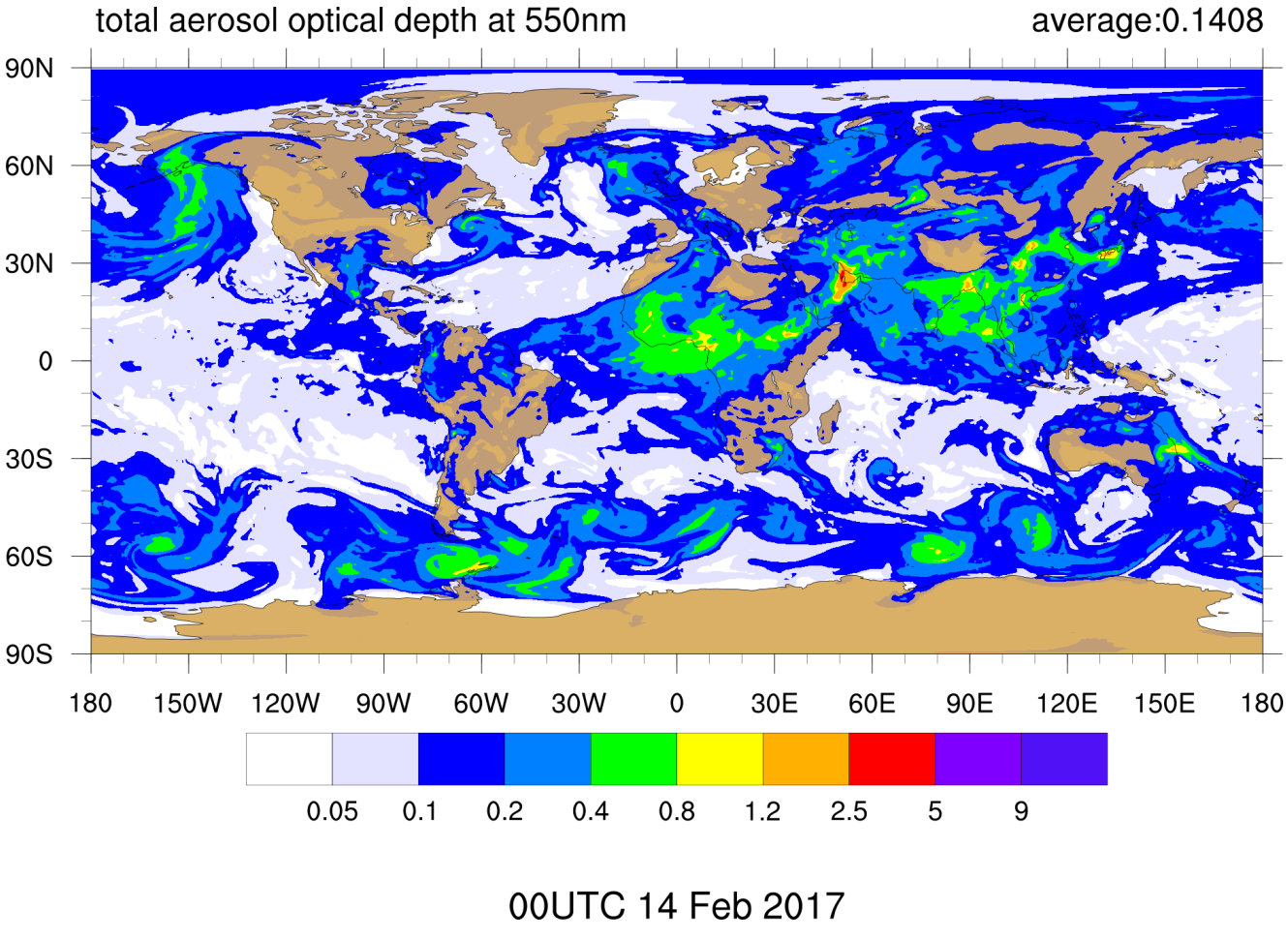
Japan Meteorological Agency has been providing Aeolian dust aerosol prediction over East Asia since January 2004. To obtain a better initial condition for the dust aerosol forecast, we are developing a near-real-time forecasting system of global aerosol distribution with data assimilation system. The prediction is calculated using a global aerosol model called MASINGAR mk-2 that is coupled to a general circulation model MRI-AGCM3. The data assimilation system uses a two-dimensional variational method (2D-VAR) and assimilates aerosol optical depth (AOD) observations by the Himawari-8 geostationary meteorological satellite and the Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra and Aqua satellites. Himawari-8 AOD retrieval is developed by Japan Aerospace Exploration Agency (JAXA) Earth Observation Research Center (EORC). We will show the impact of using Himawari-8 aerosol product for data assimilation and discuss the necessary quality control of the Himawari-8 AOD.

Keywords: aerosol, data assimilation, satellite observation



Intercontinental transport of aerosols: Results of source attribution and source/receptor relationship from HTAP2/AeroCom III model experiments

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Aerosol, also known as particulate matter (PM), is one of the major air pollutants determining ambient air quality. It also affects weather and climate through the aerosol-radiation-cloud interactions. Although its lifetime is relatively short (a few days), aerosol originated from one region can be transported to downwind regions and high altitudes to impose large scale to global influences. In this study, we will present results from multi-model experiments coordinated by the United Nations' Task Force on Hemispheric Transport of Air Pollution (HTAP) in its Phase 2 study. We first evaluate simulations by eight participating global models on (a) surface aerosol concentrations over North America, Europe, and Asia with available measurements and (b) AOD over the world with AERONET data, then we estimate the source attributions in the northern hemispheric regions of North America (NAM), Europe (EUR), South Asia (SAS), East Asia (EAS), and the Arctic (ARC), and finally we estimate the "Response to extra-regional emission reduction (RERER)" in the above regions.tr

Keywords: Transport, Aerosols, model

Impact of air pollutants on East Asian summer monsoon over China-Korea-Japan under SSP2 and RCP8.5 scenario

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We have compared two long-term simulations of SSP2 and RCP8.5 scenarios conducted using the Community Earth System Model (CESM), focusing on the changes in East Asian summer monsoon. The SSP2 scenario was applied to only China-Korea-Japan region in order to explore the impact of air pollutants on the monsoon rainfall and circulations. Results show that in the early 21st century the surface warming over the Asian continent was greater than over the North Pacific Ocean, providing greater land-sea thermal contrast in the SSP2 compared to the RCP8.5; which may intensify the East Asian monsoon system. The location of major rainfall region shifts to the north with a reduction in East Asia and an increase in subtropics. Notice that the land-sea thermal contrast has decreased in the late 21st century and the associated rainfall anomalies between the SSP2 and RCP8.5 also become reverse compared to the early 21th century. This is consistent with the reduction of 10% of CO_2 concentration and two fold increase of atmospheric aerosols over the China-Korea area in the SSP2 relative to the RCP scenario. Physical mechanisms are discussed based on the diabatic heating, adiabatic heating, and associated secondary circulation around the jet stream.

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Keywords: East Asian summer monsoon, climate pollutants, SSP scenario, CESM

Simulation of global distribution of temporal and spatial variation of $PM_{2.5}$ concentration in the future

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According to the emission scenarios of aerosols and their precursors, RCP2.6(low emission), RCP4.5(medium emission) and RCP8.5(high emission) scenarios given by the Fifth Assessment Report of Intergovernmental Panel on Climate Change (IPCC AR5), the temporal and spatial variations of the concentrations of total $PM_{2.5}$(the sum of anthropogenic and natural aerosols),anthropogenic and natural aerosols in $PM_{2.5}$ over the globe from 2010 to 2030 and 2030 to 2050, as well as the contributions of anthropogenic and natural aerosols to these variations under the green emission scenario (RCP4.5) over China are simulated in this work, using an aerosol-climate online coupled model from National Climate Center. Results show that from 2010 to 2030, the spatial variations of the column concentrations of $PM_{2.5}$ under the three emission scenarios are basically similar to each other. The column concentrations of $PM_{2.5}$ increase over Europe, North Africa, and the ocean to the west of North Africa, but the increase over North Africa and the ocean to the west of it is more significant than that over Europe. However, the column concentrations of $PM_{2.5}$ decrease over the Arabian peninsula. The annual mean surface concentrations of $PM_{2.5}$ over China decrease approximately by 2.55 $\mu g/m^3$, with the anthropogenic aerosols accounting for about 28% and the natural aerosols accounting for about 72% under RCP4.5 scenario. From 2030 to 2050, the spatial variations of the column concentrations of $PM_{2.5}$ differ greatly under the three different emission scenarios. The column concentrations of $PM_{2.5}$ increase apparently over North Africa and ocean to the west of it, while decrease over East Asia under both RCP4.5 and RCP8.5 scenarios. Whereas, the results under RCP2.6 scenario are quite different from RCP4.5 and RCP8.5 scenarios. In China, the column concentrations of $PM_{2.5}$, as well as the anthropogenic and natural aerosols in $PM_{2.5}$, are reduced further than the previous period under RCP4.5 scenario, with the contributions(about 34%) of anthropogenic aerosols increasing.

Keywords: PM2.5, anthropogenic aerosol, natural aerosol, BCC_AGCM2.0_CUACE/Aero

Potential impacts of climate variability on transpacific transport of springtime Asian aerosols

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The potential impacts of large-scale circulation associated with western Pacific (WP) and Pacific-North American (PNA) patterns on transpacific transport of springtime Asian aerosols are examined using aerosol optical depth (AOD) from the Moderate-resolution Imaging Spectroradiometer (MODIS) and reanalysis data. Composite analyses reveal that the increased westerly winds are evidently observed to the north and south of the North Pacific, respectively, during WP positive (WP+) and PNA positive (PNA+) phases. Along the favorable pathways during WP+, the large amount of aerosols are more efficiently transported over the north of 40˚N, producing the increased transport probability by about 36% compared to the opposite phase (WP−). Similarly, the distinct route over the south of 40˚N during PNA+ associated with more frequent high aerosol loading days as compare to PNA−. Concurrent with these reinforcements during WP+ and PNA+, the long-range transports of aerosols emitted from northeastern and southeastern Asia can be effectively controlled by respective patterns.

Keywords: Asian aerosol, transpacific transport, MODIS AOD, western Pacific pattern, Pacific-North American pattern

Peculiarities of the vertical and geographical distribution of particulate organic matter over West Siberia

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In recent years, we have performed aerosol sampling in the atmospheric surface layer (ASL) over different regions of West Siberia in order to reveal peculiarities of the geographical distribution of particulate organic matter. Investigation of the vertical distribution in the troposphere was undertaken by means of aerosol sampling from Optik TU-134 aircraft laboratory in the atmospheric layer from 2 to 8 km during three YAK-AEROSIB campaigns (2012, 2013, and 2014). Aerosol samples were collected onto Teflon filters (PTFE membranes, GRIMM). Hydrocarbons were identified using mass spectral library databases NIST, Wiley, as well as by comparing retention times of reference compounds in model mixtures (Alkane Standard Solutions by Sigma –aldrich).
Total organic matter varied from 244.56 ng m^3 in aerosol samples collected in the ASL to 0.08 ng m^3 in the free troposphere (FT) over the Kara Sea. Significant differences were also found in the geographical distribution of POM due to different volatile organic compounds emitted by vegetation in specific regions. Differences between concentrations of POM sampled in the free troposphere over the continent and ocean can exceed an order of magnitude. Average concentration of organic compounds in the ASL is close to 30 ng m^3 and it decreases exponentially with height down to 14 ng m^3 at the top of the atmospheric boundary layer and 5 ng m^3 in the FT.

Keywords: Aerosol, Atmospere, Chemical, Organic matter

Impact of Dust Direct Radiative Effect on African Easterly Waves

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The effects of dust on African Easterly Waves (AEWs) has caught scientific attention for the last few decades, primarily because of close proximity of dust sources and AEW’ s pathways. Being the predominant synoptic-scale disturbances over tropical Africa and Atlantic during summer, AEWs act as the major weather-producing mechanism over tropical Africa and often could play a role of precursors for Atlantic tropical cyclones. Dust radiative effect can potentially influence the structure, dynamics and the periodicity by altering the temperature profile, stability, CAPE and by modifying the environmental wind shear. However, studies in the past suggest a contrasting response of AEW to dust direct radiative effect. The present study investigates the role of dust direct radiative effect on AEWs and their sensitivity to the dust induced heating as an effort to demystify the contrasting results in the past. Ensembles of high resolution global simulations have been conducted at a spatial resolution of ~25 km, using High Resolution Atmospheric Model (HiRAM) developed at GFDL, with and without dust radiative effect. To elucidate the sensitivity of AEW to shortwave heating by dust, the experiments with dust assumes three different hematite contents (Balkanski et al., 2007), 0.9%, 1.5% and 2.7% by volume, which corresponds to inefficient, standard, and very efficient dust shortwave absorption, respectively. Comparisons among various simulations suggest that the dust radiative effect enhances the AEWs intensity and changes their periodicity. It has also been shown that AEWs strength and periodicity is sensitive to shortwave absorption by dust.

Reference: Balkanski, Y., M. Schulz, T. Claquin, and S. Guibert (2007), Reevaluation of mineral aerosol radiative forcings suggests a better agreement with satellite and AERONET data, Atmos. Chem. Phys., 7, 81 - 95.

Keywords: Dust Radiative Impact, African Easterly Waves, HiRAM

Single-particle measurements of light-absorbing iron oxide aerosols and their radiative effects

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Iron oxide (FeOx) aerosols efficiently absorb solar radiation, causing a perturbation of radiation balance. A well-known FeOx aerosol is mineral dust, emitted from the erosion of arid and semi-arid soils. In addition to dust (natural FeOx), anthropogenic FeOx aerosols generated through combustion process have been reported recently. However, the size-resolved concentration of FeOx aerosols are not well understood because of the technical difficulty of single-particle measurement of FeOx particle. Furthermore, the importance of anthropogenic FeOx aerosols to climate has never been focused on. In this study, we performed ground observation of FeOx aerosols at Cape Hedo Atmosphere and Aerosol Monitoring Station (CHAAMS), Japan. We used a modified single-particle soot photometer (SP2) and transmission electron microscopy (TEM). Although the SP2 is conventionally used to measure individual black carbon (BC) particles, we applied it to measure FeOx aerosols using a new method (Yoshida et al., 2016). Optical properties of FeOx aerosols obtained by the SP2 and TEM show that the majority of FeOx aerosols were of anthropogenic origin. The mean mass concentration was 40.4 ng/m^3, approximately one third of that of BC (132 ng/m^3). We also theoretically estimated shortwave absorption of these aerosols using the size-resolved concentration observed by the SP2. The absorbing heating power of FeOx aerosols is estimated to be 2.3–6.4% of that of BC. This result indicates that anthropogenic FeOx aerosols, which has thus far not received attention, can have non-negligible light-absorbing ability comparting with brown carbon and mineral dust, well known light-absorbing aerosols.

Keywords: aerosol, iron oxide, atmospheric radiation, observation

Trial for the BC source identification by using direct observation of trace metals with ICP-MS

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Direct mass spectrometric analysis for inorganic elements of atmospheric aerosols has become possible by using a gas converter (GED) coupled with inductively coupled plasma mass spectrometry (ICP-MS). This versatile and novel analysis technique would make us possible to assess more about source, transport, mixing and modification of the atmospheric aerosols. In this presentation, trials of BC source identification was carried out by using tracers of many metalic elements determined by the GED-ICP-MS in the actual field. Black carbon was observed by using Aethalometer along with GED-ICP-MS measurement. With PMF statistical analysis as well as meteorological analysis gave major sources of BC during a week of the observation campaign.

Keywords: ICP-MS, on-site measurement, trace metal, black carbon, PMF analysis

