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S3D Presentation

S3D-1

The impacts of mineral dust aerosols on numerical weather predictions

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Aerosols play important roles in Earth's weather and climate by modifying radiative transfer due to the optical properties of aerosols. The optical properties of aerosols are determined by their chemical and microphysical characteristics that are unique. The characteristics of mineral dust vary with the dust source regions and transportation/sink processes, however, the values of single scattering albedo (SSA) at 550nm of mineral dust range in 0.99-0.80 which is higher than generic values (0.75) of dust SSA. In this study, we constructed new mineral dust SSA map for global aerosol climatology used in numerical weather prediction (NWP) models and assess the impacts of aerosols on global weather forecast. Aerosol loading was calculated with mixing ratio of 9 mode aerosols of Monitoring Atmospheric Composition and Climate (MACC) aerosols assimilation data. Aerosol optical properties were calculated by Mie theory based on observations of size and compositions. Aerosol climatology was evaluated with AERONET, MODIS, and MISR data. The aerosol loading and aerosol optical properties were implemented to the Global/Regional Integrated Model System (GRIMs, Hong et al., 2013). The GRIMs consists of a 3-D hydrostatic dynamical core based on a spherical harmonics with a horizontal resolution of T62～T510 and 64 levels (～0.3hPa) in sigma-hybrid coordinates. The verifications of mid-range forecast were carried out July 2013 and February 2014. The forecasting score of geopotential height, temperature, specific humidity, and wind fields were compared with radiosonde observation, AWS, TMPA, and CPC observations. New aerosol climatology improved the geopotential height and temperature fields while it had a negative impact on precipitation. Overall forecast scores do not change too much, however, their impacts are localized, particularly, in East Asia and Arabian Peninsula.

S3D-2

Untangling Aerosol-Cloud-Precipitation Interactions with a Prognostic Rain Scheme Applied in MIROC-SPRINTARS GCM

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General circulation models (GCMs) still have common problems in their representation of cloud-precipitation microphysics and the magnitude of aerosol-cloud interactions (ACI). It becomes recognized that GCMs tend to overestimate the lifetime effect of the ACI, which can result in too much negative radiative forcing on the climate. One possible cause for this bias is a diagnostic treatment of rain in the models. Here we test a prognostic type of rain scheme in our MIROC-SPRINTARS GCM to investigate how the treatment of precipitation can improve the regime dependence of the ACI for warm clouds. We find that both increasing and decreasing responses of liquid water path (LWP) to aerosol perturbations are obtained in the prognostic rain scheme as observed in satellite observations and large-eddy simulation in recent literature, while the traditional diagnostic scheme shows only increasing LWP response leading to stronger cloud lifetime effect. This “bidirectional” LWP responses appeared in the new scheme is also found to systematically depend on the cloud life stage. As a result, the prognostic rain scheme reduces the LWP susceptibility about 30% relative to the diagnostic one. These improvements suggest that the prognostic precipitation framework ensures advantages in process representations of not only aerosol-cloud-precipitation microphysics but also cloud system responses to aerosol perturbations with intrinsic buffered systems, which would contribute to a more realistic climate simulation.

Key words: aerosol-cloud-precipitation interactions, GCM, climate

S3D-3

The impacts of anthropogenic heat on air pollutants in Beijing during summertime

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Anthropogenic heat (AH) is produced by intensive human activities and provides additional energy in urban area. In this study, anthropogenic heat (AH) in Beijing megacity were considered and included into WRF-Chem coupled with an urban canopy model (UCM) to investigate its potential effects on meteorological variables, atmospheric diffusion, as well as distribution of pollutants in regions around Beijing in summer 2014. Two nested domains were employed, with resolution of 27 km and 9 km respectively. The larger domain covered the east part of China and the smaller domain focused on Beijing area. WRF-Chem V3.5.1 was used with Lin et al. microphysics scheme, Goddard shortwave scheme, Carbon Bond (CBMZ) chemical mechanism and MOSAIC aerosol treatment. The initial meteorological fields and boundary conditions were from the National Centers for Environmental Prediction final reanalysis data. Both the initial and boundary chemical conditions were from MOZART's (Model for OZone and Related chemical Tracers) chemical outputs. Monthly-based anthropogenic emissions of carbon monoxide, nitrogen oxides, NH3, SO2, volatile organic compounds, BC, OC, PM2.5 and PM10 were derived from MEIC emission inventory prepared by Tsinghua University of China. Biogenic emission was from the Model of Emission of Gases and Aerosol from Nature (MEGAN). The single layer UCM took urban geometry, hydrological process and anthropogenic heat into account. As to anthropogenic heat emission, the diurnal variation of urban AH were obtained based on observational data in Beijing, with higher value during daytime than at nighttime and two peaks at 08:00 and 17:00 LST, respectively. AH was added to the surface energy balance equation in a form of sensible heat in the model. Model validation demonstrated that inclusion of anthropogenic heat improved meteorological predictions in comparison with observations, especially for surface air temperature at 2m (T2). In terms of 3-days mean, Anthropogenic heat (AH) led to a maximum 0.5 C increase in T2, a 0.3 m s-1 increase in wind speed at 10m (WS10) and a 2.0% decrease in relative humidity at 2m (RH2) in the Beijing areas. By considering AH, surface ozone concentrations increased, with the maximum of 7 ppbv around Beijing, whereas PM2.5 concentrations decreased, with the maximum up to -14 μg m-3 (percent change of 13%). The anthropogenic heat release affect air pollutants through changing both boundary layer meteorology and chemical reactions.

S3D-4

Attributed anthropogenic influence on atmospheric patterns conductive to recent extreme haze over eastern China

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The frequency of Beijing winter severe haze episodes has increased substantially over the past decades, and is commonly attributed to increased pollutant emissions from China's rapid economic development. During such episodes, levels of fine particulate matter are harmful to human health and the environment, and cause massive disruption to economic activities, as occurred in January 2013. Conducive weather conditions are an important ingredient of severe haze episodes, and include reduced surface winter northerlies, weakened northwesterlies in the midtroposphere, and enhanced thermal stability of the lower atmosphere. How such weather conditions may respond to climate change is not clear. Here we project a 50% increase in the frequency and an 80% increase in the persistence of conducive weather conditions similar to those in January 2013, in response to climate change. The frequency and persistence between the historical (1950-1999) and future (2050-2099) climate were compared in 15 models under Representative Concentration Pathway 8.5 (RCP8.5). The increased frequency is consistent with large-scale circulation changes, including an Arctic Oscillation upward trend, weakening East Asian winter monsoon, and faster warming in the lower troposphere. Thus, circulation changes induced by global greenhouse gas emissions can contribute to the increased Beijing severe haze frequency.

S3D-5

Mitigation strategy of CH4 from rice paddy fields in South Korea using a process-based model

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Rice (Oryza sativa L.) is one of the most important food crops in the world. However, rice paddy fields are considered as one of the major sources of anthropogenic CH4 emissions. The objectives of this study were to estimate CH4 fluxes from a rice paddy field during rice growing seasons in South Korea and to assess the impacts of water managements on reduction of CH4 emissions using a process-based model. Three CH4 flux monitoring chamber systems installed at a rice paddy field in Gimje (South Korea) were used to measure CH4 fluxes. These measured datasets were used to evaluate the performance of the Denitrification-Decomposition (DNDC) model to simulate CH4 fluxes. A mid-late maturing rice cultivar (Shindongjinbyeo) was transplanted with a planting density with 0.15 m × 0.30 m (hill × row) on June 21, 2012 and June 21, 2013 after barely had been harvested at the study site. The DNDC model underestimated CH4 fluxes from a rice paddy field at the beginning of the rice growing seasons (overall 0.7 of R2 for the year 2013), while the DNDC model well estimated CH4 emissions during the rice growing seasons. The DNDC model was used to assess the impacts of continuous flooding (CF) and midseason drainage (MSD) on CH4 emissions. This study suggests that the DNDC model can be used to assess efficacious mitigation strategies to reduce the greenhouse gases.

S3D-6

Verification of Asian dust in source region using ADAM2 model in first half of 2017

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The Asian Dust Aerosol Model 2 (ADAM2) is operating as Asian dust forecast model by Korea Meteorological Administration. ADAM2 is optimized in East Asia region and also can reflect seasonal variability of Asian dust by adapting seasonality of threshold wind speed, threshold relative humidity, and reduction factor. In first half of 2017, the tendency of overestimation of Asian dust in source region is found in ADAM2. Verification of Asian dust in source region in ADAM2 is required to improve forecast ability. PM10 and PM2.5 observation data by Ministry of Environment Protection (MEP) of China are used to set standard concentration for discrimination of Asian dust event in source region. In case of PM2.5/PM10 ratio less than 0.4, the frequency of PM2.5/PM10 with respect to PM10-PM2.5 distinctively increases starting from the PM10-PM2.5 concentration of 200 μ g m-3. Because coarse particles are dominant in Asian dust contrast to anthropogenic areosol, PM2.5/PM10 ratio less than 0.4 proportion can be regarded as Asian dust constitution ratio with respect to whole particulate matter. Therefore, 200 μ g m-3 is considered as standard concentration to determine Asian dust in PM10-PM2.5 observation. Standard concentration (200 μ g m-3) of observation is applied to ADAM2 to determine Asian dust event. Because there might be time delay or precedence between ADAM2 and MEP observation due to uncertainty of ADAM2 simulation, Asian dust event of ADAM2 can have up to 12 hour difference based on observed time. ADAM2 Asian dust forecast is evaluated by using accuracy indices. Probability of detection (POD) and false-alarm ratio (FAR) are used to evaluate Asian dust event of ADAM2. Where POD shows low value, ADAM2 is difficult to forecast due to surface condition determining Asian dust emission. Where FAR is high, emission is overestimated due to high wind speed, low relative humidity or low reduction factor. POD shows low value in Taklamakan desert and FAR shows high value in western part of Manchuria. Western part of Manchuria shows false alarm of Asian dust in source region reported in February and March in 2017. Meteorological conditions such as wind speed, surface temperature, relative humidity, or precipitation determine existence of dust emission. Meteorological field of ADAM2 is evaluated by using Global Telecommunication System (GTS) in first half of 2017. Surface temperature of ADAM2 shows almost same feature of observed surface temperature in GTS in whole period. Precipitation of ADAM2 shows low value compared to GTS observation. However, because spatial distribution of precipitation is complex and discontinuous, it is difficult to compare precipitation of ADAM2 with precipitation of GTS one-on-one. Wind speed of ADAM2 tends to underestimate in Mongolia compared to wind speed of GTS. However, in Manchuria, wind speed of ADAM2 overestimates with respect to wind speed of GTS. Overestimated wind speed of ADAM2 tends to exceed threshold wind speed in source region which can make false alarm of Asian dust in source region. Relative humidity of ADAM2 is slightly overestimated in eastern part of Manchuria. However, in western part of Manchuria, relative humidity of ADAM2 shows slightly low value compared to relative humidity of GTS. Underestimated relative humidity of ADAM2 tends to be lower than threshold relative humidity value in source region which also can make false alarm of Asian dust in source region. By evaluating meteorological variables of ADAM2 with those of GTS, we anticipate to contribute improvement of the performance of ADAM2.