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Abdalla

Aerosol Pollution and its Impact on Precipitation

Zakaria Abdalla

key words: Aerosol, Pollution, Precipitation

Life on the earth is critically dependent upon the continuous cycling of water between oceans, continents and the atmosphere. Precipitation (including rain, snow and hail) is the primary mechanism for transporting water from the atmosphere back to the Earth's surface. It is also the key physical process that links aspects of climate, weather, and the global hydrological cycle. Changes in precipitation regimes and the frequency of extreme weather events, such as floods, droughts, severe ice/snow storms, monsoon fluctuations and hurricanes are of great potential importance to life on the planet. One of the factors that could contribute to precipitation modification is aerosol pollution from various sources such as urban air pollution and biomass burning. Natural and anthropogenic changes in atmospheric aerosols might have important implications for precipitation by influencing the hydrological cycle, which in turn could feed back to climate changes. From an Earth Science perspective, a key question is how changes expected in climate will translate into changes in the hydrological cycle, and what trends may be expected in the future. We require a much better understanding and hence predictive capability of the moisture and energy storages and exchanges among the Earth's atmosphere, oceans, continents and biological systems. This article is a review of our knowledge of the relationship between aerosols and precipitation reaching the Earth's surface and it includes a list of recommendations that could help to advance our knowledge in this area

Alvim

Evaluation of CAM-chem simulations with CO and aerosol satellite data and investigation of Fire Radiative Power with CO and AOD observations

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key words: Brazilian Earth System Model, carbon monoxide, aerosol optical depth, Fire Radiative Power, CAM-chem Model

Researchers in Brazil are currently developing their own atmosphere-ocean-biosphere-cryosphere Global Circulation Model – the Brazilian Earth System Model (BESM). BESM simulations demonstrate great potential to contribute to the international efforts on global climate and climate change research within the Brazilian climate modeling community. Currently, the Center for Weather Forecasting and Climate Studies of the National Institute for Space Research (CPTEC/INPE) in Brazil is working

towards the implementation and tests of the aerosol and chemistry components in the BESM project. The components of aerosols and chemistry that are being implemented in the Brazilian Atmospheric Global Model (BAM) of BESM are derived from the atmospheric component of the Community Earth System Model (CESM) named Community Atmosphere Model (CAM) which has modal representation of aerosols, MAM3, and MOZART being the chemistry component. This study compares the global data of carbon monoxide from the MOPITT satellite with the CAM model using a version with tropospheric chemistry and another identical version, but with stratospheric chemistry. The tropospheric chemistry has 103 species and stratospheric mechanism with 122 species, including heterogeneous reactions. The simulations are also compared for aerosol optical depth (AOD) with MODIS satellite and investigates the relationship of CO, AOD, Fire Radiative Power measurements obtained from satellite over the globe for identifying aerosols from burning.

Andrews

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Update on AeroCom INSITU Project: Comparison of aerosol optical properties from in-situ surface measurements and model simulations

Elisabeth Andrews

key words: in-situ,aerosol optical properties

In the spring of 2015 AeroCom initiated a project ‘INSITU’ comparing model output to in-situ, surface-based measurements of aerosol optical properties. The model/measurement comparison project, called INSITU, aims to evaluate the performance of a suite of AeroCom aerosol models with observations from the approximately 60 surface sites which have submitted their data to the World Data Centre for Aerosols (http://ebas.nilu.no/). The three tiers of the INSITU project are intended to look at how well models reproduce (i) observed in-situ aerosol optical property climatologies and co-; (ii) aerosol hygroscopicity; and (iii) aerosol trends.Previously, preliminary comparisons of model/in-situ aerosol optical comparisons focused on data from the ~30 surface sites in the NOAA collaborative network. The analysis has now been expanded to include an additional 30+ sites which have submitted aerosol optical data to the World Data Center for Aerosols archive. New comparisons indicate that model output of both single scattering albedo and scattering Angstrom exponent tend to be lower (i.e., aerosol is darker and larger) than the in-situ observations. Additional results showing improved analysis of aerosol optical property co-variances and the importance of temporal matching (e.g., Schutgens et al., 2016) will be presented.

Aoki

Temporal and spatial variability of Aerosol optical properties retrieval from sky radiometer observation in Japan sites.

Kazuma Aoki

key words: Aerosol optical properties, validation of satellite and model data

Aerosols play an important role in the Earth climate change. We started the long-term monitoring of aerosol optical properties since 1990’s by using sky radiometer (Prede Co. Ltd., Japan). We provide the information, in this presentation, on the aerosol optical properties with respect to their temporal and spatial variability in Japan site. The global distributions of aerosols have been derived from earth observation satellite and have been simulated in numerical model, which assume optical parameters.

However, these distributions are difficult to derive because of variability in time and space. Therefore, Aerosol optical properties were investigated using the measurements from ground-based sky radiometer. The sky radiometer is an automatic instrument that takes observations only in daytime under the clear sky conditions. Observation of diffuse solar intensity interval was made every ten minutes by once. The aerosol optical properties were computed using the SKYRAD.pack version 4.2. The obtained Aerosol optical properties (Aerosol optical thickness, Ångström exponent, Single scattering albedo, and etc.) and size distribution volume clearly showed spatial and temporal variability. In this study, we present the temporal and spatial variability of Aerosol optical properties at several Japan sites, applied to validation of satellite and numerical models. The GCOM-C satellite scheduled to be launched in JFY 2016.

Arola

Retrieval of aerosol optical depth from surface solar radiation measurements using machine learning algorithms, non-linear regression and a radiative transfer-based look-up table

Antti Arola, Jani Huttunen, Tero Mielonen, Mika Mononen, Antti Lipponen, Juha Reunanen, Anders Lindfors, Santtu Mikkonen, Kari Lehtinen, Natalia Kouremeti, Alkis Bais, Harri Niska and Harri Kokkola

key words: Aerosol Optical Depth, Surface Solar Radiation, Machine Learning Algorithms

In order to have a good estimate of the current forcing by anthropogenic aerosols, knowledge on past aerosol levels is needed. Aerosol optical depth (AOD) is a good measure for aerosol loading. However, dedicated measurements of AOD are only available from the 1990s onward. One option to lengthen the AOD time series beyond the 1990s is to retrieve AOD from surface solar radiation (SSR) measurements taken with pyranometers. In this work, we have evaluated several inversion methods designed for this task. We compared a look-up table method based on radiative transfer modelling, a non-linear regression method and four machine learning methods (Gaussian process, neural network, random forest and support vector machine) with AOD observations carried out with a sun photometer at an Aerosol Robotic Network (AERONET) site in Thessaloniki, Greece. Our results show that most of the machine learning methods produce AOD estimates comparable to the look-up table and non-linear regression methods. All of the applied methods produced AOD values that corresponded well to the AERONET observations with the lowest correlation coefficient value being 0.87 for the random forest method. While many of the methods tended to slightly overestimate low AODs and underestimate high AODs, neural network and support vector machine showed overall better correspondence for the whole AOD range. The differences in producing both ends of the AOD range seem to be caused by differences in the aerosol composition. High AODs were in most cases those with high water vapour content which might affect the aerosol single scattering albedo (SSA) through uptake of water into aerosols. Our study indicates that machine learning methods benefit from the fact that they do not constrain the aerosol SSA in the retrieval, whereas the LUT method assumes a constant value for it. This would also mean that machine learning methods could have potential in reproducing AOD from SSR even though SSA would have changed during the observation period.

Bai

Prediction of ground-level PM2.5 concentrations from 3km resolution MODIS AOD over southern Jiangsu

Heming Bai and Minghuai WANG

key words: Aerosol Optical Depth, mixed effects model, PM2.5 prediction

PM2.5 concentrations with high temporal and spatial resolutions can be derived basing on satellite products. By using the 3 km resolution satellite aerosol optical depth (AOD) data and PM2.5 concentrations measured at 73 PM2.5 monitoring sites between Jan 2014 and Mar 2016 in southern Jiangsu, the eastern province in China, a mixed effects model was applied to predict ground daily PM2.5 concentrations in the corresponding region. The result of comparisons between the observed and predicted concentrations showed good performance in the model. The coefficients of determination (R2) for AOD-PM2.5 relationship varied from 0.72 to 0.78 in different period (whole period, warm season and cold season). R2 of cross-validations slightly decreased but still maintained higher levels with the value varied from 0.62 to 0.68. Consequently, the mixed effects model was a reliable approach to predict PM2.5 concentrations in the study region.

Bergman

Validation of aerosol optical properties of EC-Earth and stand-alone TM5

Tommi Bergman, Twan van Noije and Philippe le Sager

key words: GCM, EC-Earth, TM5,Aerosol,Optical properties

Aerosols play an important role in global and regional climate change as they change the Earth's radiation balance through direct and indirect effects. The scattering and absorption of radiation and modification of cloud properties constitute the largest single uncertainty in the radiative balance of the atmosphere. In this study we focus on the direct shortwave effects, and evaluate aerosol optical properties simulated by the global aerosol model TM5 as part of the global climate model EC-Earth and as a stand-alone chemistry and transport model (CTM). In TM5 aerosols are represented by the modal microphysics module M7 in combination with an extensive tropospheric chemistry scheme. The climate model used for this study is a recent development version of EC-Earth 3.2. A final version of this model will be used for production runs in CMIP6, AerChemMIP and other MIPs. Tuning of the physical GCM core of the model has started only recently. Three different model configurations have been considered in this study: 1) an atmosphere-only version of EC-Earth, 2) an atmosphere-only version of EC-Earth with nudging of temperature, wind and surface pressure fields to ERA-Interim reanalysis data, and 3) a stand-alone version of TM5 driven by offline meteorological fields from the same reanalysis. The nudged EC-Earth and stand-alone TM5 simulations are evaluated by comparing the simulated aerosol optical properties to observational data, in particular ground-based observations from AERONET sun photometer sites, and the MODIS Collection 6 Level-2 AOD satellite product. We will also present and discuss present-day climatologies of aerosol optical properties and the associated direct radiative effects obtained in atmosphere-only climate simulations.

Bian

Investigation of global nitrate and its impact on air quality from AeroCom Phase III experiment

Bian, H., M. Chin, D. Haugluztaine, M. Schulz, G. Myhre, S. E. Bauer, T. L. Kucsera, X. Pan, R. B. Skeie, S. D. Steenrod, K. Sudo, K. Tsigaridis, K. Vlassis

key words: Nitrate experiment, air quality

In this talk, we intend to wrap up the AeroCom III nitrate study by analyzing the simulations provided by seven AeroCom models. To gain confidence levels of model performance, we will first evaluate the model results with various observations globally including ground station measurements for tracer concentrations and dry and wet depositions, as well as aircraft measurements for tracer vertical distributions. We will then conduct budget analyses to understand tracers' typical magnitude, distribution, and diversity among the models. Given the unique chemical and physical features of nitrate simulation, we will further investigate the similarity and differentiation of nitrate simulation among the models by examining: 1) the source of nitrate precursors and nitrate chemical mechanism; 2) the ammonia wet deposition; and 3) the ratio of nitrates between fine mode and coarse mode.

Chantara

Chemical composition of PM2.5 from near source and urban sites in Chiang Mai, Thailand during biomass burning season

Somporn Chantara, Chanakarn Khamkaew, Tippawan Prapamontol

key words: Air pollution, PM2.5, Biomass burning, Levoglucosan, Potassium ion

Biomass burning (BB) is a significant source of air pollution in South East Asia including Northern Thailand. It is a common practice in agricultural areas after harvesting. Open burning including agricultural residue burning as well as forest fires emits huge amount of aerosols into the atmosphere causing smoke haze covers large area over the region. Aerosol samples (particulate matter with an aerodynamic diameter less than or equal to 2.5 µm; PM2.5) from near BB source (DAK) and urban (CMU) sites of Chiang Mai Province were collected in BB period (March to mid-April 2014) on daily basis using mini volume air samplers. Two samples (24-hr sampling) were collected at each site a day. The samples were extracted and analyzed for their chemical composition (water soluble ions and levoglucosan). The average PM2.5 concentrations at CMU (92.5 ± 32.7 µg m-3) were well correlated (r = 0.8) with those at DAK (82.0 ± 33.8 µg m-3) with no significant difference. The major ions at both sampling sites were SO42- (30–38% of total ions), NO3- (13–20%) and Na+ (16–20%). Average concentration of levoglucosan (BB tracer) at DAK (1.38 ± 0.60 µg m-3) was slightly higher than at CMU (1.13 ± 0.70 µg m-3). Concentrations of PM2.5 and K+ were highly correlated (r = 0.7 – 0.8) at both sites indicating that PM2.5 samples are probably originated from the same source (BB). Moreover, concentrations of levoglucosan and K+ were also correlated (r = 0.5 for CMU and 0.7 for DAK) confirming that aerosols in these areas were mainly emitted from BB activities. It also reveals that during the smoke haze episode air pollutants spread over and cover large area. Long range transport is another important issue affecting air quality in the downwind areas.

Chin

Aerosols in the upper troposphere and lower stratosphere (UTLS): Composition, origin, and transport pathways from the AeroCom3/HTAP2 model experiments

Mian Chin

key words: Aerosols, UTLS

We present a study on the aerosol composition at the UTLS region from several global models participated in the AeroCom3/HTAP2 coordinated model experiments. The model results will be compared with the aircraft observations from CARIBIC in the upper troposphere and satellite

observations in the UTLS region. With tagged emissions from anthropogenic and biomass burning emissions, we attribute the origin of the UTLS aerosols in terms of the source location (polluted regions) and source type (anthropogenic, biomass burning, volcanic or other natural sources). We will further examine the role of monsoon system that transports materials from the lower atmosphere to the UTLS region. Finally, we will discuss the idea on the proposed AeroCom3/UTLS experiments that can be coordinated with the SSiRC and ACAM communities.

Chineke

Determination of elemental composition of in-door and out-door petrol generator aerosols and their health implications in electricity-deficient communities

Theodore Chineke, Ijeoma David-Okoro, Victor Dike, Ferdinand Iwuagwu

key words: aerosol,generators,pollutants,air quality and health

We are concerned that power outages in recent years led to many members of the public purchasing generators of various sizes; a purchase that introduces a life-threatening hazard into the home or workplace etc. Aerosol samples were collected from seven sites were chosen in Owerri Municipal, Imo State Nigeria as an example of an electricity-deficient community, where some particulate matters were collected. These samples were later analyzed using atomic absorption spectrophotometer. The average results for iron in parts per million(ppm) for these sites are as follows: St Mulumba (660.023); Erekwerenwa (735.623); Buka (443.817); Gods own line (450.406); Wethedral (407.61); A/c line upstairs (620.867) and A/c line downstairs (444.953). The average results in ppm for Manganese for all the sites are as follows: St Mulumba (11.298); Erekwerenwa (11.608); Buka (7.674); Gods own line (6.118); Wethedral (6.385); A/c line upstairs (9.721) and A/c line downstairs that was 6.468ppm. The result for lead was nil for all locations while copper read nil for all locations except for Wethedral which recorded 25.47 (ppm). Standard samples are graded by United States Environmental Protection Agency (EPA) on a scale of 0 to 500, indicating how many parts per million ppm contain these pollutants. A sample of 0 to 50 ppm indicates good air quality; 50 to 100 ppm indicates moderate air quality; 100 to 200 ppm, is unhealthy air quality; 200 to 300 ppm, indicates very unhealthy air quality; while 300 to 500 ppm, indicates hazardous air quality. The average results for iron in all the locations were found to be high while manganese was found to be moderate in all the locations.

de Leeuw

Evaluation of aerosol properties over China using multiple satellite instruments (MarcoPolo)

Gerrit de Leeuw, Larisa Sogacheva, Edith Rodriguez, Mikhail Sofiev, Julius Vira, Vassilis Amiridis, Eleni Marinou, Emmanouil Proestakis, Kostas Kourtidis, Aristeidis K. Georgoulias, Yong Xue, Ronald van der A

key words: Satellite remote sensing, Aerosol characterisation, China, 3D distribution, time series

The main objective of the EU-FP7 project MarcoPolo is to improve air quality monitoring, modelling and forecasting over China using satellite-retrieved information on aerosols, NOx, SO2, and biogenic gases. This information will be used in air quality models to invert emission estimates. The results, together with known information from ground-based measurements, will then be used to construct an emission database over China. In this contribution we report on the use of satellite data to obtain information on aerosol properties over China. Several different instruments, in particular MODIS, AATSR and CALIOP,

are used to provide the spatial AOD since 2002. CALIOP also provides information on the vertical structure of aerosols, including aerosol type information in particular on dust. A merged AOD product, constructed using in addition MISR and SeaWiFS data, provides improved AOD coverage. The AOD data sets are validated and evaluated versus sun photometer data from AERONET and the Chinese network CARSNET. This is particularly valuable because aerosol retrieval algorithms are developed and validated over areas where many independent ground-based observations are available, such as over the eastern USA and Europe. However, over these areas the AOD levels are often relatively low as compared to China where the occurrence of very high AOD, combined with the variation in aerosol type and surface characteristics, poses particular problems as regards data selection and discrimination between high AOD and the occurrence of clouds. An initial analysis of the spatial and vertical variability of the AOD will be presented together with time series showing the variation over representative areas. Satellite derived information on aerosol precursor gases NO2, SO2 and BVOCs will be used in the analysis.

DEV KHATRI

Variations in trends of atmospheric aerosols over Pakistan & their impact on cloud parameters

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key words: Satellite remote sensing, trajectory modeling

Aerosol optical depth (AOD), cloud cover, water vapor, cloud top temperature and cloud top pressure profile data from the Moderate Resolution Imaging Spectroradiometer (MODIS Terra satellite) are used to investigate the variation of aerosols in time and space and also their impact on clouds during Feb 2000 –Feb 2011 over Pakistan. The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model for trajectory analysis is used to explore the source region of pollution and to find out its path on which it travels on spatial and temporal basis. Trajectories and Angstrom exponent correlation maps revealed that the major source of pollution is mineral dust blown from local deserts and also from deserts of neighboring countries. During winter season the region is affected by biomass burning aerosols transported from Indian Ganges Plain (NW India). It is found that increasing AOD throughout the study period exerts a strong effect on cloud properties over Pakistan. The highest values of AOD observed in the southern part of the country during summer season (JJA), whereas the lowest values occurred during winter season. It is found that the 2008 remained the most polluted year during the entire study period. Four cloud parameters namely water vapor (WV), cloud fraction (CF), cloud top temperature (CTT) and cloud top pressure (CTP) were analyzed together with AOD for which annual and seasonal correlation maps and time series plots were produced. The correlation for CF with AOD is strongly positive in the southern part than in the northern part which may be attributed to high concentration of hygroscopic aerosols in the south. Seasonal Correlation coefficient for CF was strongly significant in autumn season as compared to other seasons for all the cities except Lahore which showed less significant correlation. The correlation between AOD and water vapor showed strong positive correlation in northern parts (Rawalpindi corr.coefficient=0.83) than the southern parts. The higher AOD in the northern parts may be the result of cloud contamination most probably by cirrus clouds which prevail at higher latitudes. Seasonal correlation coefficients for water vapor v/s AOD showed strong positive correlation in Spring and Autumn seasons for all the six cities but less significant in winter and summer seasons indicating that may be the meteorological factors are influencing this relationship. In northern parts of Pakistan the spatial correlation between cloud top temperature and AOD was strongly positive. This may be due to less cloud fraction and dominance of fine mode aerosols whereas it was negative for southern parts as a result of high cloud fraction and abundance of coarse mode aerosols. In spring season the correlation for CTT v/s AOD was strongly positive for all the cities, whereas it was strongly negative for Karachi (-0.4) in autumn season and for Zhob (-0.4) in summer season. The correlation between cloud top

pressure and AOD was strongly negative for southern part and positive for northern part because CTT is negatively correlated with CTP. The results for seasonal variation of correlation coefficient of AOD v/s cloud top pressure showed strong positive correlations in spring season for Karachi (+0.39), Lahore (+0.72), Multan (+0.72) and Rawalpindi (+0.34) while it showed strong negative correlation for Karachi (-0.54) in autumn and Zhob (-0.5) in summer season.
Aerosols and cloud parameters are not only related through microphysics, but also their relationship depends on meteorological conditions. However, interpretation of the complex relationships between AOD and cloud parameters should be made with great care and further work is clearly needed.

Di Biagio

Global scale variability of the mineral dust longwave refractive index: a new dataset for climate modelling and remote sensing

Claudia Di Biagio, Paola Formenti, Yves Balkanski, Lorenzo Caponi, Mathieu Cazaunau, Edouard Pangui, Emilie Journet, Sophie Nowak, Sandrine Caquineau, Meinrat Andreae, Konrad Kandler, Thuraya Saeed, Stuart Piketh, David Seibert, Earle Williams, Jean-Francois Doussin

key words: mineral dust, longwave refractive index, mineralogy, global scale variability

In this study we explore the variability of the mineral dust longwave refractive index (CRI) as a function of its mineralogical composition and size distribution by in situ measurements in the 4.2 m3 CESAM chamber (Experimental Multiphasic Atmospheric Simulation Chamber). Mineral dust aerosols were generated from 19 natural soils and sediments from Northern Africa, Sahel, Middle East, Eastern Asia, North and South America, Southern Africa, and Australia. These were selected to represent major dust sources worldwide and to account for the heterogeneity of the soil composition at the global scale. The generated aerosols were re-suspended in the chamber, and their longwave extinction spectra (2-16 µm), size distribution, and mineralogical composition were measured. The generated dust aerosol exhibits a realistic size distribution and mineralogy. The CRI of dust was obtained by optical inversion based on extinction and size data.
Results from the present study show that the longwave CRI of dust strongly varies both in magnitude and spectral shape from sample to sample, following the variability of the particle composition. For instance, the strength of the absorption at ~7 and 11.4 µm depends on the amount of calcite within the samples, while the absorption at 8-14 µm is determined by the abundance of quartz and clays. Our data also show that the CRI of dust does not modify with time due to the loss of coarse particles by gravitational settling.
The unique dataset presented in this study is of great relevance for both climate modelling and remote sensing applications since: 1) our results permit taking into account the geographical variability of the dust longwave CRI, which at present is not represented in climate models and satellite retrievals; 2) our findings support the common practice to treat the dust longwave CRI as static during transport, which would strongly simplify its representation.

Du

Modeling investigation of rapid formation of a regional extreme severe winter haze episode covering a mega-city cluster in North China Plain

Huiyun Du, Jie Li

key words: Haze, apportionment, vertical profile, source

The Nested Air Quality Prediction Model System (NAQPMS) with an on-line tracer-tagged module was used to investigate the rapid formation and sources of a regional extreme severe haze episode over a mega-city cluster in North China Plain in Nov. 26 Nov-1 Dec 2015, in which regional daily mean PM2.5 exceeded 500μg/m-3. We found that the accumulation of regional transport at the foot of mountain accounted for the rapid increasing and sustaining stage of highest surface PM2.5 on 30 Nov.-Dec.1 in Beijing, although concentrations of PM2.5 in source regions were lower. Local contribution was dominated in the slow increasing stage (26-29 Nov.). In vertical, large differences on source appointments appeared on different layers below 1km above ground level in Beijing, even in the stable conditions. Contributions from local emissions and its neighboring regions sharply decreased from the ground to 1 km. For regional transport, the altitude of main transport body slowly increased, as the distance of source regions to Beijing became farther and farther. The transported PM2.5 from southern Hebei and Henan province centered around 200-400m and 300-700m, respectively, with maxima of 100-120μg/m-3. These results suggested that more attention should be paid on point sources on 200-500m in BTH and its surrounding provinces because they were located in the effective transport height. Differently from Beijing, Tianjin was controlled by the regional transport and cities in Hebei provinces mostly resulted from local emissions in this episode. The tagging on time in haze periods showed that PM2.5 on hazy days had been aged because PM2.5 formed in previous one or two days was twice of that formed in “current day”, which suggested that control-measures should be made two days prior to haze episode.

Fairlie

Characterizing the Asian Tropopause Aerosol Layer using balloon measurements, satellite observations, and a chemical transport model

Thomas Fairlie, Hongyu Liu, Jean-Paul Vernier

key words: aerosol, monsoon

Satellite observations and numerical modeling studies have demonstrated that the Asian Summer Monsoon (ASM) provide a conduit for gas-phase pollutants in south Asia to reach the lower stratosphere. Now, observations from the CALIPSO satellite have revealed the Asian Tropopause Aerosol Layer (ATAL), a summertime accumulation of aerosols in the upper troposphere and lower stratosphere (UTLS), associated with the ASM anticyclone. The ATAL has potential implications for regional cloud properties, climate, and chemical processes in the UTLS. Here, we show in situ measurements from balloon-borne instruments, aircraft, and satellite observations, together with trajectory and chemical transport model (CTM) simulations to explore the origin, composition, physical, and optical properties of aerosols in the ATAL. In particular, we show balloon-data from our BATAL-2015 field campaign to India and Saudi Arabia in summer 2015, which includes in situ backscatter measurements from COBALD instruments, and the first observations of size and volatility of aerosols in the ATAL layer using optical particle counters (OPCs). Back trajectory calculations initialized from CALIPSO observations point to deep convection over North India as a principal source of ATAL aerosols. Available aircraft observations suggest significant sulfur and carbonaceous components to the ATAL, which is supported by simulations using the GEOS-Chem CTM. Source elimination studies conducted with the GEOS-Chem indicate that ATAL aerosols originate primary from south Asian sources, in contrast with some earlier studies.

Fan

An Atmospheric Correction Algorithm for FY3/MERSI data over land in China

Cheng Fan, Jie Guang, Yong Xue, Aojie Di, Lu She, Yahui Che

key words: MERSI, Surface Reflectance, FY3, SARBA

Medium Resolution Spectral Imager (MERSI), which enables images of the Earth with high spatial resolution and high temporal resolution, is an important sensor carried by on-orbit Chinese polar orbiting meteorological satellite Feng-Yun (FY-3). Prior to the derivation of various biophysical parameters based on surface reflectance, the atmospheric effects are necessary to be removed, especially in land surface remote sensing and applications. The potentiality of the retrieval of surface reflectance using FY3/MERSI data was studied. This paper presents an atmospheric correction algorithm for FY3/MERSI in visible to near-infrared band over land in China. Previous operational correction schemes have assumed a Lambertian surface. This atmospheric correction algorithm is developed to take into account the directional properties of the observed surface by a kernel-based Bi-directional Reflectance Distribution Function (BRDF) model. This model was applied to FY3A/MERSI and FY3B/MERSI for retrieving surface reflectance over land in China. The comparison of MODIS surface reflectance product with ASD reflectance showed that there is a good agreement. Furthermore, spatial resolution of MERSI is superior as compared to that of MODIS. Therefore, FY-3/MERSI can serve a reliable and new data source for quantifying global environmental change.

Feng

Increased absorption by brown carbon: impact on black carbon radiative effect

Yan Feng, Xiaohong Liu, Rao Kotamarthi

key words: brown carbon, radiative forcing

Large uncertainty in the estimated black carbon (BC) direct radiative forcing (0.25~1.09 Wm-2) can be attributed to differences between the modeled and observed solar absorption by aerosols. One of the contributing factors is due to the absorbing organic carbon, also known as brown carbon (BrC). In this study, we present a global simulation of BrC with the latest four-mode version of the Modal Aerosol Module (MAM4) in the Community Atmosphere Model version 5 (CAM5), and examine the nonlinear effects on the estimated BC forcing due to the enhanced absorption by BrC. The spectrally-resolved absorption by BrC from primary emissions is parameterized for biomass burning, biofuel and fossil fuel sources, respectively. The CAM5 model estimates that BrC contributes about 12% of the fine-mode aerosol absorption at 550nm on a global average, and plays a more significant role in major biomass burning regions. Since BrC undergo atmospheric processes different from BC, inclusion of BrC changes the simulated vertical distribution of atmospheric absorption. As a result, the vertical transport of BC to the upper troposphere is suppressed. The increased absorption by primary BrC inserts a positive radiative effect of +0.04 W m-2, but decreases the estimated BC radiative forcing from +0.56 to 0.5 Wm-2. Regionally, this impact on the BC forcing is more significant with larger positive and negative changes ranging from -0.4 to +0.2 Wm-2. The simulated changes of meteorological and cloud fields due to inclusion of BrC absorption will be discussed on the estimation of BC radiative forcing.

Garay

Improvements to the MISR Operational Aerosol Product Including Cloud Screening, Uncertainty, and Microphysical Properties

Michael Garay, Michael Bull, David Diner

key words: Aerosols, MISR

Since early 2000, the Multi-angle Imaging SpectroRadiometer (MISR) instrument on NASA's Terra satellite has been providing operational Level 2 (swath-based) aerosol optical depth (AOD) and particle property retrievals at 17.6 km spatial resolution. The performance of this product, designated Version 22, has been validated against ground-based Aerosol Robotic Network (AERONET) observations, model comparisons, and climatological assessments. MISR aerosol data have also played a major role in studies of the impacts of aerosols on climate and air quality. Motivated by the needs of the air quality community and tests on algorithm performance, a new version of the MISR aerosol product, designated Version 23 has been developed. The resolution of the Version 23 product has been increased to 4.4 km, allowing more detailed characterization of aerosol spatial variability, especially near local sources and in urban areas. The product content has been updated and simplified to benefit users.
We will describe the major upgrades incorporated in Version 23 and the efforts to improve cloud screening, incorporate per-retrieval uncertainty, and the reporting of microphysical properties.

Gettelman

Using Volcanic Emissions to Estimate Aerosol-Cloud Interactions

Andrew Gettelman, Anja Schmidt, Jon-Egill Kristjansson, James Haywood

key words: aerosol cloud interactions, volcanoes

Effusive volcanic emissions of sulfur dioxide (SO2) are a significant part of the global sulfur budget, and represent a natural laboratory for trying to understand and simulate the effects of sulfate aerosol on clouds. Several recent and on-going volcanic eruptions in marine environments offer particularly useful natural experiments that can be used to constrain models. A recent example is the 2014 Holuhraun rift eruption in Iceland, which released a large amount of SO2 into the N. Atlantic in the fall and early winter of 2014-2015, and likely perturbed cloud properties significantly. A second example is the continuous eruption of Kilauea in Hawaii, which has been emitting SO2 into the marine boundary layer since 1983. While both cases offer opportunities for model validation, the continuing effusive eruption of Kilauea offers the opportunity for more comprehensive intermodal evaluation of aerosol cloud interactions. A proposed field field project aims to provide a comprehensive data set that can be used to intercompare AEROCOM models and try to better constrain aerosol-cloud interactions.

Interaction of Aerosol Forcing and Climate Feedbacks

Andrew Gettelman

key words: aerosol cloud interactions, climate model

Aerosols can influence cloud radiative effects, and thus may alter interpretation of how the earth's radiative budget responds to climate forcing. Three different ensemble experiments from the same climate model with different greenhouse gas and aerosol scenarios are used to analyze the role of aerosols in climate feedbacks and their spread across initial condition ensembles of transient climate simulations. An aerosol kernel is introduced to remove effects of aerosol cloud interactions that alias into cloud feedbacks. Adjusted cloud feedbacks indicate an `aerosol feedback' resulting from changes to climate that increase sea-salt emissions, mostly in the S. Ocean. Ensemble simulations also indicate higher tropical cloud feedbacks with higher aerosol loading. These effects contribute to a difference in

cloud feedbacks of nearly 50\% between ensembles of the same model. Thus aerosols can be a significant modifier of cloud feedbacks, and different representations of aerosols and their interactions with clouds may contribute to multi-model spread in climate feedbacks and climate sensitivity in multi model archives.

Ginoux

Anthropogenic dust experiment: Sensitivity to landuse datasets and surface winds

Paul Ginoux, Bing Pu

key words: Dust, Landuse

It has been estimated that 10 to 25% of dust emission is from agriculture. As soils have been disturbed by human activities, aeolian dust from such soils is attributed an anthropogenic origin. Most recent estimate of anthropogenic emission rely on satellite data, rather than models. The advantage of satellite data is the direct observation of dust over cropland and pasture, while model estimation rely on fitting observations far from dust sources. As dust lifetime is of the order of a week, poorly constrained removal processes made model results quite uncertain. Such drawbacks are eliminated by direct observations. Still, the location of cropland and pasture varies from year to year and between datasets. Another important source of error is parameters of dust emission, in particular the velocity threshold of wind erosion. This threshold is a function of soil texture, soil moisture, vegetation cover, and any non-erodible elements lying on the ground. In order to evaluate uncertainties associated with landuse datasets, we perform a sensitivity study using all landuse datasets available. Using daily global 0.1x0.1 degrees resolution MODIS Dust Optical Depth and high resolution re-analysis, we will show that it is possible to derive a velocity threshold of wind erosion on the same high resolution. Comparison of the results with ground-based data over East Asia indicates very good agreement. Still, these values cannot be directly used by models with coarser resolution and different physics. We will show how to solve this problem, and how to apply our method to other models participating to the Aerocom "Anthorpogenic Dust Experiment" Hopefully, this work will attract other modelers to participate to the "Aerocom anthropogenic dust" in order to assess the contribution of anthropogenic dust to atmospheric dust load and ultimately its impact on climate before the 2020 deadline of paper submission for IPCC WG1.

Dust emission derived from satellite based surface extinction

Paul Ginoux, Juliette Paireau

key words: Dust, Landuse

Dust emission in the semi-arid Sahel remains challenging due to the large seasonal and interannual dynamics of surface properties. The increasing conversion of rangelands into croplands raises issues concerning wind erosion. Surface data are too sparse over West Africa to estimate dust emission from landuse. Satellite data is the most commonly used set observations to study dust events in West Africa. Aerosol products retrieved from MODIS instrument were recently used to estimate dust emission from natural and anthropogenic sources globally and regionally, including Sahel. A major issue with satellite data over Sahel is that dust plumes may be elevated during part of the year. In such conditions, deriving dust sources in line with elevated plumes is incorrect.
We have developed a statistical model combining MODIS with CALIOP extinction profiles to derive surface extinction over West Africa. Comparison with surface dust concentration at 3 sites in Sahel indicates similar variability. With this new product we infer the frequency of occurrence (FoO) of dust events originating from Sahel. The FoO maxima correspond to the most probable dust sources. These

sources are compared with previous dust source inventories based on satellite data (MODIS, TOMS, MISR, MSG-SEVIRI,etc.) An additional uncertatinty when estimating dust emission is the velocity threshold of wind erosion. This velocity corresponds to the minimum surface wind necessary to start dust erosion. Below this threshold, there is no dust emission. Its value depends on soil texture, soil moisture, vegetation cover, and any elements lying on the soil surface. All these factors are unknown or highly uncertain, and most models use a fixed value globally. Here, we show that we can derive in arid or semi-arid regions its value knowing the FoO of dust events and the 6-hourly surface winds from ECMWF re-analysis. The results are compared with in-situ data over Sahel. Using simple parametrization of dust emission, we finally calculate the best estimate of natural and anthropogenic dust emissions over West Africa and compare them with values from the litterature.

Goto

High resolved aerosol simulations using a non-hydrostatic atmospheric transport model (NICAM)

Daisuke Goto, Teruyuki Nakajima

key words: aerosol transport model, very high resolution

One feasible way to properly simulate aerosols is to run the model with high-resolved horizontal grid sizes, since the aerosols and their precursors are emitted from localized hot spots in the industrial or urban areas as well as biomass burning areas. Under this concept, an atmospheric aerosol-chemistry model coupled to a global nonhydrostatic model has been developed (Suzuki et al., 2008; Goto, 2014; Goto et al., 2015). The aerosol module is based on Spectral Radiation-Transport Model for Aerosol Species (SPRINTARS: Takemura et al., 2005). The dynamic model is Nonhydrostatic Icosahedral Atmospheric Model (NICAM; Tomita and Satoh, 2004; Satoh et al., 2008; 2014), which originally has a uniform grid system with various grid spacing, can concentrate horizontal grid points at a region of interest using a Schmidt transform scheme (Tomita, 2008). As a result, horizontal grid intervals gradually become smaller at the focusing region to save computational resources (it is called as ‘stretched grid system’). Firstly, NICAM with the stretched grid system, O(10km) around Tokyo, were integrated during one-month in August. The model with O (10km) was capable of consistently recreating accurate fields of meteorological variables, primary and secondary aerosols to those obtained by in-situ measurements. Secondly, the simulation was extended from regional to global scales with 14 km grid spacing using the K computer at RIKEN in Japan. The global aerosol simulation with such high resolution are performed during 1-years for the first time. These successes absolutely help us to understand the aerosol-cloud interaction in a global scale, to estimate high-resolved distributions of human health impacts due to aerosols (e.g., Goto et al., 2016), and to develop a new aerosol-chemistry climate model with O (10km) grid spacing near the future.

Griesfeller

The AeroCom infrastructure in a changing IT environment

Jan Jürgen Griesfeller, Michael Schulz

Key words: AeroCom, IT

Modern IT trends also influence the way science projects have to work. Because of Met Norway's move of its main IT infrastructure to a private cloud, the replacement of the AeroCom infrastructure looks

much different from how it was 5 years ago. Instead of private servers that not always suited our needs during end of project times, we have now a central infrastructure that can easily serve peak needs from AeroCom while still providing computing power to other projects when AeroCom does not need them. My poster will show how the new cloud based AeroCom infrastructure looks like and what benefits and problems the change to cloud based services caused.

Gryspeerdt

Constraining the climate forcing by aerosol-cloud interactions using present day aerosol-cloud relationships

Edward Gryspeerdt, Johannes Quaas

key words: aerosol, forcing, anthropogenic perturbations

Much of the uncertainty in climate change forcing comes from uncertainties in the radiative forcing due to aerosol-cloud interactions. As aerosols serve as cloud condensation nuclei (CCN) can have a strong influence on the cloud droplet number concentration (CDNC), previous studies have investigated the sensitivity of the CDNC to aerosol properties as a way of constraining the strength of the aerosol forcing. However, recent studies have suggested that the sensitivity in the present day climate may not be suitable for determining the sensitivity of the CDNC to anthropogenic aerosol perturbations. The sensitivity, dCDNC/dCCN, is only a mean to calculate the anthropogenic change in CDNC, dCDNC(anth), which is then used to calculate the radiative forcing due to aerosol-cloud interactions. As such, it is suggested here that the ability of the present day statistics to predict the change in CDNC is a more relevant test. In this work, global aerosol-climate models are used to show that it is possible to predict the change in CDNC due to anthropogenic aerosols to a high accuracy using present day aerosol-cloud relationships and knowledge of the anthropogenic aerosol perturbation.

Grzegorski

A new operational EUMETSAT product for the retrieval of aerosol optical properties over land (PMAp2)

Michael Grzegorski, Ruediger Lang, Andriy Holdak, Gabriele Poli, Alessandra Cacciari, Rosemary Munro

key words: aerosol optical depth, satellite retrieval

The retrieval of aerosol optical properties is an important task for industry and climate forecasting. An ideal instrument should include observations with moderate spectral and high spatial resolutions for a wide range of wavelengths (from the UV to the TIR), measurements of the polarization state at different wavelengths and measurements of the same scene for different observation geometries. As such an ideal instrument is currently unavailable the usage of different instruments on one satellite platform is an alternative choice. Since February 2014, the Polar Multi sensor Aerosol product (PMAp) is delivered as operational GOME product to our customers. The algorithms retrieve aerosol optical properties over ocean (AOD, volcanic ash, aerosol type) using a multi-sensor approach (GOME, AVHRR, IASI). The product is now extended to pixels over land using a new release of the operational PMAp processor (PMAp2). The data of the new PMAp processor is disseminated to our users since March 2016. This presentation gives an overview on the new operational product PMAp2 with a focus on the validation of the PMAp aerosol optical depth over land. The impact of different error sources to the results (e.g.

surface contribution to the TOA reflectance) is discussed. We also show first results of upcoming extensions of our PMAp processor, in particular the improvement of the cloud/aerosol discrimination of thick aerosol events (e.g. volcanic ash plumes, desert dust outbreaks).

Hsu

Retrieving aerosol plume height information by synergetic use of VIIRS, OMPS and CALIOP observations

Christina Hsu, Jaehwa Lee, Corey Bettenhausen, Andrew Sayer, Colin Seftor

key words: Aerosol plume height, Air quality, Satellite retrieval, Aerosol absorption

In recent years, satellite measurements of AOD have been used to predict ground-level particulate matter concentrations for air quality applications. However, these AOD-to-PM conversions are dependent on knowledge of the vertical distribution of aerosols in the atmosphere. Aerosol altitude information is also useful for evaluating chemistry transport models, or determining potential for their long-range transport, in particular for smoke and dust plumes. Compared to the urban pollutants, these types of plumes could reside at much wider range of altitude, often intruding into free troposphere. Therefore, the capability of deriving plume heights and identifying the types of these aerosols over wide spatial regions would be highly desirable for both air quality application and climate forcing studies. Recent advances in satellite remote sensing technique (both in instrumentation and retrieval algorithms) have allowed for retrieving extinction profile from Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) in its operational data processing stream. However, information over broad areas is not readily achieved from CALIOP observations due to its narrow swath width. This study presents a method for retrieving the plume height and single scattering albedo of UV-absorbing aerosols, such as dust and biomass burning smoke, in a much broader area than CALIOP observations by combining aerosol products from multiple satellite sensors: aerosol optical depth (AOD) from Visible Infrared Imaging Radiometer Suite (VIIRS), UV aerosol index (UVAI) from Ozone Mapping and Profiler Suite (OMPS), and aerosol total backscatter coefficient from CALIOP. We will show the results of retrieved aerosol plume height and single scattering albedo using this approach during the biomass burning events as well as over the dust outbreak regions. The performance of the resulting aerosol plume height and single scattering albedo will also be evaluated against ground based lidar and AERONET measurements, respectively. Finally, the strength and weakness of this approach will be discussed.

Hu

Climatology (2002–2014) of aerosol products derived from MODIS, MISR and OMI sensors over the Yangtze River Delta

Kang Hu, Na Kang, Raghavendra Kumar Kanike

key words: MODIS, AOD, Aerosol Index, East China, Aerosol type

Long-term (2002–2014), simultaneous data on aerosol optical properties from MODIS, MISR and OMI satellite sensors are analyzed to study their temporal characteristics and to infer on the major aerosol types present over an urban city, Nanjing in the Yangtze River Delta, East China. The present study aims to investigate spatio-temporal evolution and trend in the aerosol optical properties (AOD, AE, and AI), qualitatively identify different types and origin of aerosols. An inter-comparison and validation of

satellite AOD were performed against the AERONET AOD. The MODIS AOD550 exhibited wide spatial and temporal distributions over East China. The temporal variations (monthly and seasonal mean) of MODIS (Terra and Aqua) and MISR AOD values exhibited a similar pattern. The seasonal mean AOD550 (AE470-660) was found to be maximum with 0.97 ± 0.48 during summer (1.16 0.33 in summer) and a minimum of 0.61 ± 0.28 during the winter season (0.80 0.28 in spring). The annual mean Terra AOD550 at Nanjing showed a strong decreasing trend (–0.70% year-1), while the Aqua exhibited a slight increasing trend (+0.01 year-1) during the study period. Seasonal air mass cluster backward trajectories obtained from the HYSPLIT model were also computed to infer on the transport component over the study region. Different aerosol types were classified via the clustering technique AOD550 vs AE470-660, which reveals that the biomass burning/urban-industrial (BB/UI) type aerosols (desert dust) are abundant over the region in summer (spring), apart from the mixed aerosol type. Further, sub-classification of the aerosols has been done on an annual basis taking into account of OMI derived AI. Considering the urban/industrial nature of the study location, the BB/UI type aerosols have been significantly underestimated to study the different categories of absorbing aerosols.

Jayawardena

Numerical simulation of air pollution dispersion in a lee side wake – A case study at south western part of Sri Lanka

H. K.Wasana Isuri Jayawardena, Leif Enger

key words: air pollution dispersion, mesosclae simulation, lee side wake

Air pollution is becoming an increasing threat over the heavily populated south western region in Sri Lanka during past decades and hence important to study the pollutant dispersion patterns of area sources. In the North East Monsoon, a lee side wake and a counter rotating vortices could observe at the southwest part. The effects of lee side wake, vortices and the central mountain area on dispersion of air pollutants were examined using mesoscale simulations. Simulations of pollutant concentrations and other weather fields were made with the MIUU-model (Meteorological Institute Uppsala University model) for 5 km resolution. The simulations were done for 12 days period from 16th to 28th February, 1999. The pollutant dispersion of two area sources at south-western region were studied. The area sources were assumed as 5 km x 5 km in size with inert substance of 100 gs-1. The simulations showed accumulation of air pollutants in the wake vortices. Lower concentrations were observed in the center of the clockwise vortex compared to the concentration in the counter clockwise vortex. Further the vertical diffusion was more pronounced in the positive vortex area. The pollutants in the low were trapped and followed the vortex for several hours. The study provides the pollutant dispersion patterns associate with the lee vortices observed during the North East Monsoon, which can be used in air quality impact assessments. Further the influence of complex terrain especially the significant control of central mountain area on air pollutant dispersion and ambient air quality over southwestern part of the Sri Lanka was identified.

Jiang

Seasonality in Anthropogenic Aerosol Effects on East Asian Climate Simulated with CAM5

Yiquan Jiang, Xiu-Qun Yang, Xiaohong Liu

key words: aerosol climate effects, East Asia,seasonality

This study investigates the seasonality in anthropogenic aerosol distributions and their effects on clouds and precipitation in East Asia with the Community Atmospheric Model version 5. The differences between the model experiments with and without anthropogenic emissions exhibit a monsoon circulation induced northward shift of the maximal aerosol optical depth change in East Asia from March to July and then a southward withdrawal from September to November. Associated with the shift, the direct and semi-direct effects of the anthropogenic aerosols are the most pronounced in spring and summer, with a maximum center in North China during summer and a secondary center in South China during spring. The cloud liquid water path and shortwave cloud forcing changes, however, are the weakest in North China during summer. The indirect effect is found to be the strongest in South China during spring, which is related to the large amount of middle-low level clouds in cold seasons in East China. A positive feedback between aerosol induced surface cooling and low-level cloud increase is identified in East China, which acts to enforce the aerosol indirect effect in spring. Accordingly, the climate response to the anthropogenic aerosols is also characterized by a northward shift from spring to summer, leading to a spring drought in South China and a summer drought in North China. The spring drought in South China is attributed to both direct and indirect effects of the anthropogenic aerosols, while the summer drought in North China is primarily determined by the aerosols' direct effect.

Guang

Aerosol Optical Depth Retrieval in Xinjiang Region Using Indian National Satellite (INSAT 3D) Data

Jie Guang, Aojie Di, Yong Xue, Xihua Yang, John F. Leys, Linlu MEI

key words: AOD, aerosol type, INSAT 3D, Xinjiang,dust

Taklimakan Desert, encompassed in Xinjiang, is one of the predominant dust origins in China. Dust is one of the main types of atmospheric aerosol. Indian National Satellite (INSAT 3D) is suitable for dust aerosol retrieval for Xinjiang region as it can provide high spatiotemporal earth observations with a spatial resolution of 1km in 30-minites interval, which are very applicable for aerosol optical depth (AOD) retrieval. However, the joint retrieval of aerosol types and AOD remains difficult in bright underlying surface using satellite data, though some work have been done with other geostationary satellites (Govaerts et al. 2010; Kim et al. 2008; Mei et al. 2012). The purpose of this paper is to propose an improved algorithm to retrieve AOD over bright underlying surface using ISNAT 3D data. Firstly, six predefined aerosol types are introduced into a previous AOD retrieval algorithm (Li et al., 2013). AOD and aerosol types in desert area are derived simultaneously utilizing this improved algorithm. The retrieved AOD is then validated using MODIS AOD product, which shows a squared correlation coefficient of 0.80. Meanwhile, a cross validation between INSAT3D-retrieved aerosol types and MSIR ((Multi-angle Imaging Spectro-Radiometer) aerosol types product (Kahn and Gaitley 2015; Kahn et al. 2010) shows a great consistency. More than 80 percent of valid pixels get the same types.

Kahn

AeroCom Biomass Burning Emissions Experiment Phase 2: A fire emission plume injection height parameterization

Maria Val Martin, Ralph Kahn, Mariya Petrenko, Mian Chin

key words: Smoke Plumes, Injection Height, Stereo Height, Source Characterization, MISR

To accurately represent fire emissions in chemical transport and climate models, knowledge of the fire emission injection height is critical. Currently, a wide range of arbitrary assumptions and elaborate plume-rise parameterizations based on empirical and physical approaches are used to represent the vertical distribution of fire emissions. However, at present they are poorly constrained. Within the AeroCom-coordinated multi-model Biomass Burning experiment we have proposed to test a fire smoke injection height parameterization to be used in future large-scale biomass burning studies. We developed this parameterization from statistical summaries of worldwide, multi-year MISR plume height stereoscopic observations. The parameterization consists of fire emission fractions based on plant functional types and land cover units, and is stratified by altitude, region and ecosystem. We have implemented the scheme in the Community Earth System Model and do a preliminary testing. Here, we will present the MISR-based fire emission height parameterization, and results from the first evaluation with CESM. The parameterization is available for testing with other aerosol transport models, as part of Phase 2 of the AeroCom Biomass Burning Emissions Experiment. We will outline plans for the coordinated modeling experiment as part of the presentation.

Kalashnikova

From Climate to Air Quality: Polarimetric Characterization of Speciated Airborne Particulate Matter

Olga Kalashnikova, Feng Xu, Michael Garay, Longtao Wu, David Diner

key words: MAIA, Speciated PM

Ambient particulate matter (PM) is the top environmental risk factor worldwide, responsible for nearly 3 million premature deaths per year. Although there is a scientific consensus that exposure to PM increases the risks of death and disease, the relative toxicity of specific PM types—components having different size and chemical composition—is poorly understood. We demonstrate how data from the Multi-angle Imaging SpectroRadiometer (MISR) instrument that has been flying on NASA's Terra Earth Observing System satellite since 1999 can be used to provide estimates of surface PM concentrations. As a proof-of-concept, MISR high-resolution 4.4 km aerosol retrievals were combined with surface air pollution and meteorological measurements over Southern California. Spatio-temporal statistical models were built and cross-validated upon these combined data, resulting in an approach to reliably retrieve near-surface PM. Although MISR retrievals worked well for total PM2.5, we found limited sensitivity to PM10 or to PM2.5 components. To improve particle type sensitivity, we introduce and evaluate a new approach for retrieving near-surface and atmospheric airborne PM types using information contained in multi-angle, spectropolarimetric remote sensing imagery constrained with a first-guess on aerosol chemical type and optical properties from a chemical transport model (CTM). The CTM vertical profile is used to convert total column aerosol properties differentiated by particle type to near-surface speciated PM. We tested the approach using Airborne Multiangle SpectroPolarimetric Imager (AirMSPI) data collected over the California Central Valley during recent field campaigns, and from a high-resolution (4 km) Weather Research & Forecasting (WRF)-Chem aerosol model over the same domains at the time of AirMSPI overpasses. We find that WRF-Chem-constrained AirMSPI retrievals of speciated PM show better agreement with ground-based observations (order of 30% difference) than WRF-Chem model predictions alone (order of 5-10x underestimation). We conclude with a discussion of plans for future field campaigns and introduce the Multi-Angle Imager for Aerosols (MAIA) instrument that was recently selected under NASA's third Earth Venture Instrument call. MAIA will provide new information that enables estimates of speciated (size- and particle type- stratified) surface PM from space over major cities around the globe, and will yield improved associations between particulate air pollution and human health.

Khushi

Utility Asset Management System of WASA – A GIS based approach for sustainable service delivery

Sana Khushi

key words: asset management, Water Supply

Efficient integration of utility asset data (water supply) and geographical information system (GIS) is the key for a successful utility system. Poor asset management system (AMS) can lead to poor strategic policies and weak long term planning. Location is the most important information while studying water supply system. Through this GIS integration leads to better visualization of our data and can keep check on the performance of utility systems and services. GIS would help water supply system authorities to overcome the challenges of data integration and management for effective decision making for future planning.This paper describes the approach to develop the GIS based asset management system for water supply system, referred as Water Supply Asset Management System (SWAMS), through spatial and non-spatial data integration, field verification and analysis. is the combination of data, software, processes, field verification, analysis and finally output such as risk level identification, cost, condition assessment and renewal time required etc. The process of schematic mapping and data conversion using paper records, Computer Aided Design (CAD) maps and information entered in GIS based AMS ensured the accurate and sufficient information for effective management. The results of this system will be in the form of maps that will be shared with all the stakeholders such as asset management authorities and policy making departments. This exercise is done initially in Shahdara water supply sub-divisions of Lahore, Punjab.

Kinne

Revisiting aerosol module assessments in AeroCom

Stefan Kinne

key words: model assessment, AOD and mass

More than 10 years have passed since AeroCom initially evaluated (component mass and aod) of global models participating in AeroCom exercises. Since then results of many new models and new versions of models were allowed to enter the AeroCom data-base without detailed assessments about their performance. In efforts to establish characteristic or central values from global modeling recently submitted model output were combined. However, even without outliers (using local interquartile averages) the results for AOD in some regions were rather strange. Thus, an evaluation of all and especially new submissions is urgently needed. For this reason all modeling groups participating in AeroCom exercises were asked to provide a reference simulation for the year 2010. Data from these submissions are analyzed and results are compared to those ten years ago.

The MAC aerosol climatology

Stefan Kinne

key words: aerosol climatology, optical properties

Aerosol is highly diverse in space and time. And many different aerosol optical properties are needed (consistent to each other) for the determination of aerosol radiative effects and forcing. To sidestep the complex (and uncertain) aerosol treatment of bottom up estimates (emission to mass to optics by components) a monthly gridded climatology for aerosol optical properties has been developed. This MPI Aerosol Climatology (MAC) is tied to observational statistics for aerosol column optical properties from sun-/sky- photometry and completed with spatial distribution patterns from global modeling to fill data-gaps. In order to extend MAC applications (1) aerosol microphysical properties are derived to permit estimates for CCN and IN for estimates of aerosol cloud interaction and (2) even aerosol component single scattering properties are offered. An application presents spatial distributions of aerosol radiative effects.

The climate impact of black carbon

Stefan Kinne

key words: black carbon, radiative forcing

The black carbon aerosol component (often referred to as soot) strongly absorbs solar energy. The resulting local warming not only impacts atmospheric dynamics but also reduces the solar reflection to space, especially if the lower boundary condition is highly reflecting (such as clouds, snow/ice or deserts). The reduction means that (solar) energy is retained in the Earth-Atmosphere yielding in effect a climate warming. This warming aspect of anthropogenic added BC is usually accompanied by an even stronger cooling of other co-emitters (such as sulfates). Therefore singling out reductions of BC in potential mitigations to reduce climate warming by CO2 is not quite fair (even when ignoring difference and spatial and temporal effects). Nonetheless, some studies focusing just on the BC. Many of such studies with claims to observational data suggest strong climate warming by (anthropogenic) BC, much higher than bottom-up estimates from global models of about +0.3W/m2 globally - to the point that climate model results are questioned. In this contribution the absorption information of ground-based sun-/sky-photometry is used to constrain aerosol absorption by black carbon. The deduced climate warming by black carbon is found that the BC warming is larger than in most global models: globally and annually averaged near +0.8W/m2 at TOA and near +2.4W/m2 in the atmosphere – quite consistent with the estimate given in Bond et al., 2013.

Kirkevåg

Aerosol validation and effective radiative forcing estimates from a preliminary version of CAM5-Oslo

Alf Kirkevåg, Kari Alterskjær, Alf Grini, Matthias Hummel, Trond Iversen, Inger Helene Karset, Jon Egill Kristjansson, Anna Lewinschal, Dirk Olivie, Michael Schulz, Øyvind Seland

key words: aerosol validation, effective radiative forcing

We present preliminary aerosol validation results and effective radiative forcing (ERF) estimates from simulations with CAM5-Oslo, using nudged meteorology and IPCC AR5 emissions of aerosols and precursors for present day (2000) and pre-industrial (1850) conditions. Aerosol validation will mainly be performed using AeroCom scripts for comparison with observations. Following Ghan (2013), ERF by anthropogenic aerosols is split into an ARI term (aerosol radiation interactions, i.e. direct radiative forcing), an ACI terrn (aerosol cloud interactions, containing indirect and semi-direct effects), and a surface albedo forcing term. Each of the ERF terms can further be split into short-wave and long-wave components. ERF estimates will be compared to IPCC AR5 results. CAM5-Oslo is an early version of the next generation atmospheric module of the Norwegian Earth System Model, NorESM1 (Bentsen et

al., 2013; Iversen et al., 2013; Kirkevåg et al, 2013). It is basically an extended version of CAM5 (Liu et al., 2012) where schemes for aerosol chemistry, physics and interaction with clouds originally developed for NorESM1 exist as options alongside the modal aerosol modules of CAM5. Important upgrades in aerosol chemistry and physics since NorESM1: revised sea-salt aerosol treatment (Salter et al., 2015), explicit nucleation (based on Makkonen et al., 2014) and SOA, interactive DMS and marine POM. Development of nitrate aerosol as part of the aerosol scheme is still ongoing. If results including nitrate are ready, some of these may also be presented.

Kolahchi

The relationship between characteristics of physiographic and dust storm phenomena in Khuzestan, Iran

Abdolnabi Kolahchi, Ali Akbar Noroozi

key words: dust storm, wind erosion

The Khuzestan province is one of the population centers in the South West of Iran where a vast significant proportion of important and strategic infrastructure of the country located in this province that developed in recent decades. Due to the geographical location of the province and adjacent western neighbors has been faced with natural disaster that dust storm is one of the most important natural hazard phenomena. Due to the multiple consequences of this phenomenon in large and small scales, identification of dust storm generation area in province, identify potential areas of erosion, planning and better manage of this phenomenon and its cost reduction is important to consider. The construction and topography of the Khuzestan plain is a continuation of the Mesopotamian plain that become a suitable location for wind erosion and dust storm as well. The aim of this study is to investigate the relationship between physiographic characteristics, geology and soil with dust storm phenomenon in Khuzestan province. Examination of zones prone to dust showed that the sensitivity of formation happen in the high and very high class with low resistance. Soil characteristics of the study area showed that the majority of the area are sand dunes, marshy soils, saline and alkaline soils, where these area most susceptible to erosion vulnerability. Given that in this zone, the average slope and the range of slope change in the area decline, the risk of erosion is very high.
dust storm, wind erosion

Identification of the areas with potential dust storm sources based on physiography and climatic features (Khozestan, Iran)

Abdolnabi Abdeh Kolahchi, AliAkbar Noroozi

key words: Dust Storm Sources, Remote Sensing

The aim of this study is to identify sources areas of potential generation of internal dust storm in the Khuzestan province. For this purpose, a combination of statistical method, remote sensing and modeling were used. Several data such as daily synoptic stations in Khuzestan province, the daily images of MODIS, Landsat sensors, U and V data from Nova website and land use changes over the period 2015-2000 were used. The results of daily data processing of dust storm codes shows that the most frequent occurrence of dust storm at the annual time scale in Khuzestan province was recorded during 2008 and 2009. Most occurrences of dust storm based on seasonal scale and monthly scale happened in the late spring and early summer and in May, June and July respectively. Based on hourly time scale, most dust storm phenomena was recorded at 15:30 pm local time (12 GMT). Investigation on occurrence of dust storm detection based on satellite imagery and check the amount of dust's concentration from AOD and BTD imagery indicate greatest concentration of dust happened in West

and South-West province of Khuzestan, Since dust map areas with more than 80% of dust storm frequency happened in area which consistent with the results of statistical data. Tracking the dust entering by using the backtracking particles techniques and map of wind speed and direction showed that during the warm period, most dust entrance from northwest - southeast and west – east and for the end of cold period, the dust storm entranced from south – north which effect Khuzestan Province. Investigation of land use change during the period 2015-2000 shows the followings: irrigated areas and vegetation cover (30%) decreased whereas soil arid land increase in 2015, especially in the west side of Khuzestan. These features and physiographic features such as the erodibility of formations, salty soil and swampy, low soil moisture, a great land use changes indicates the presence of prone areas and potential for dust storm for the West and southern Khuzestan province. Therefor the decision-making and necessary planning in organizations have to perform in order to prevent the intensification of this phenomenon and, if possible, stand and confront with the frequency dust occurrence for west and the southern area of province.

Kühn

Modeling black carbon: from international cliamte law to impact on Arctic Climate (white)

Thomas Kühn, Harri Kokkola, Kaarle Kupiainen, Kati Kulovesi, Kari Lehtinen

key words: global modeling, black carbon, Arctic

The WHITE project is a novel multi-disciplinary collaboration between the UEF Law School, the Finnish Environmental Institute (SYKE) and the UEF Aerosol Research Group. Its ultimate goal is to identify national and international regulatory options that have the highest potential in mitigating arctic warming. To this end, different regulatory frameworks are analysed and used to construct emission scenarios, whose long-term impact on the Arctic climate is then assessed using global climate modelling. Here we present first results showing the importance of the correct spatial and temporal distribution of emissions on pollutant concentrations in the arctic. For our simulations we used the global aerosol-climate model ECHAM-HAMMOZ (ECHAM6.3-HAM2.2) with the sectional aerosol module SALSA. We compare two different aerosol emission inventories. The ACCMIP II emission inventory, which is the standard ECHAM emission inventory, is by default restricted to yearly average emissions. In contrast, the ECLIPSE emission inventory contains detailed monthly variations for the relevant emission sectors and regions. Additionally, the ECLIPSE emission inventory includes flaring emissions from oil production, which make a large contribution to Arctic pollutant concentrations. Even though the yearly average BC emission strengths do not differ much between the two emission inventories, the BC burdens seen in the Arctic region are clearly higher for the ECLIPSE emission inventory. This higher BC burden is thus caused by both the higher temporal resolution of the emissions and the inclusion of the flaring emissions caused by oil production.

Lacagnina

Aerosol Single Scattering Albedo: comparing PARASOL, OMI and MISR retrievals

Carlo Lacagnina, Otto Hasekamp

key words: Aerosol SSA, PARASOL, OMI, MISR intercomparison

Estimates of aerosol radiative forcing are characterized by high uncertainty, mainly because of insufficient accuracy of single-scattering albedo (SSA) observations. We compare three independent

satellite products providing SSA at 0.44 um during 2006: PARASOL [based on multi-angle multispectral (0.44-1.02 um) photo-polarimetric measurements], OMI [intensity-only (0.35-0.50 um)] and MISR [multi-angle multispectral (0.45-0.87 um) measurements]. Preliminary results indicate that OMI SSA exhibits best agreement against ground-based AERONET observations, but compares worst in terms of AOD. Vice-versa characterizes MISR retrievals. On the other hand, PARASOL offers the best compromise in quality for SSA and AOD products. Furthermore, PARASOL shows high SSA variability, while MISR has little sensitivity to low SSAs.

Aerosol direct radiative effect based on PARASOL and OMI satellite observations

Carlo Lacagnina, Otto Hasekamp

key words: PARASOL & OMI, aerosol direct radiative effect

Accurate portrayal of the aerosol characteristics is crucial to determine aerosol contribution to the Earth's radiation budget. We employ novel satellite retrievals to make a new measurement-based estimate of the shortwave direct radiative effect of aerosols (DREA), both over land and ocean.Global coverage satellite measurements of aerosol optical depth (AOD), single-scattering albedo (SSA) and phase function from PARASOL (Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar) are used in synergy with OMI (Ozone Monitoring Instrument) SSA. Aerosol information is combined with land-surface Bi-directional Reflection Distribution Function (BRDF) and cloud characteristics from MODIS (Moderate Resolution Imaging Spectrometer) satellite products. Eventual gaps in observations are filled with the state-of-art global aerosol model ECHAM5-HAM2. It is found that our estimate of DREA is largely insensitive to model choice. Radiative transfer calculations show that DREA at top-of-atmosphere is -4.6 +- 1.6 W/m^2 for clear-sky and -2.1 +- 0.6 W/m^2 for all-sky conditions, during year 2006.These fluxes are consistent with, albeit slightly less negative over ocean than, former assessments. Unlike previous studies, our estimate is constrained by retrievals of global coverage SSA, which may justify different DREA values. Remarkable consistency is found in comparison with DREA based on CERES (Clouds and the Earth's Radiant Energy System) and MODIS observations.

Lee

Is climatological aerosol optical depth averaged over the last 16+ years stationary?

Huikyo Lee, Michael Garay, Olga Kalashnikova

key words: MISR, climatological aerosol optical depth, model evaluation

Atmospheric aerosol distributions and temporal variations have significant impacts on the Earth’s radiation budget, yet even their mean state in the current climate requires further investigation. To obtain insights into important aspects in the simulated aerosols and their radiative forcing in AeroCom models, it is not only important to constrain the models with aerosol optical depth (AOD) from satellite observations, but also to identify uncertainties in observed AOD. Due to its unique multiangle viewing approach, the Multi-angle Imaging SpectroRadiometer (MISR) instrument on NASA's Terra satellite is capable of distinguishing mixtures of aerosol types without relying on data from other instruments. Using the AOD data for different aerosol types from MISR and AeroCom models, this study will characterize the stationarity of climatological AOD in the observation and models as a function of sampling period. Specifically, our study aims at 1) determining if the 16-year measurement record from MISR is long enough to define AOD climatology, and 2) providing guidance to evaluate climatological characteristics of optical depth for different types of aerosols in AeroCom models. To assess the uncertainty in climatological AOD, seasonally averaged AOD and AOD distribution in each year are

calculated using the MISR observation and Aerocom hindcast simulation output. The random subsampling of seasonally averaged AOD values and AOD distributions will allow us to map the minimum periods required to obtain reliable climatological AOD distributions at each grid point. Some preliminary analysis of the MISR AOD climatology shows that the MISR data for 16 years provide stationary climatology of AOD. However, in some regions such as Amazon and Maritime continent, the 16-year period may not be long enough to build climatology of seasonal AOD. The results also indicate the need for longer satellite observations to obtain reliable climatological AOD by components for evaluation of AeroCom simulations.

Levy

Using the Dark Target retrieval to create an aerosol climate data record

Robert Levy, Shana Mattoo, Virginia Sawyer, Yingxi Shi, Falguni Patadia, Pawan Gupta, Richard Kleidman, Yaping Zhou, Lorraine Remer

key words: Dark-Target, MODIS

Aboard NASA's Terra (since 2000) and Aqua (since 2002) satellites, the Moderate resolution Imaging Spectroradiometer (MODIS) sensors have been observing the Earth in spectral bands that cover the wavelength spectrum of reflected solar radiation. We have been applying the "Dark-Target" (DT) aerosol retrieval algorithm to derive aerosol optical depth (AOD) over land and ocean and Angstrom Exponent (AE) over ocean. Now in Collection 6 (C6), the two MODIS time series are mostly similar, but there are some puzzling systematic differences. In attempt to further homogenize C6-Terra and C6-Aqua, we are quantifying sampling differences and calibration offsets. Yet, even when homogenized, the 16-year MODIS dataset is still too short to be considered an aerosol climate data record (CDR). Therefore, we need additional sensors to continue MODIS, as well as to interpret what we already have. We have ported the DT algorithm to the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard Suomi-NPP (SNPP; launched 2011) and see that the DT-VIIRS time series is similar to C6-Aqua. Again, however, there are systematic differences including nearly a 20% bias over the global oceans. As we work to close the gaps between these sensors in polar-orbit (MODIS on Terra, MODIS on Aqua, and VIIRS on SNPP), we are applying DT to other sensors with similar spectral observations. For example, using MODIS Airborne Simulator (MAS; aboard aircraft since 1996), we seek to use the factor-of-ten better spatial resolution to quantify cloud effects within MODIS pixels. By porting DT to the new generation of geostationary satellites (e.g. Advanced Imagers on GOES-R and Himawari), we can observe the diurnal cycle of aerosol/cloud fields. In turn, this will help to quantify differences between the morning (Terra) and afternoon (Aqua) MODIS data records. The ultimate goal is creating a DT dataset as a legitimate aerosol CDR.

Lewinschal

Regional aerosol emissions and temperature response: Local and remote climate impacts of regional aerosol forcing

Anna Lewinschal, Annica Ekman, H.-C. Hansson, Joakim Langner

key words: aerosol forcing, remote temperature response

The spatial distribution of anthropogenic aerosol emissions and concentrations vary substantially over the globe, and hence, the aerosol radiative forcing. Regional aerosol radiative forcing can nevertheless

influence the temperature response field far away from the forcing region through e.g. heat advection and changes in the atmospheric and ocean circulation. Moreover, the global temperature response, including the spatial temperature response distribution, may vary depending on the geographical location of the forcing. In other words, aerosol emissions and forcing in one region can result in a surface temperature change pattern different from that resulting from aerosol emissions and forcing in another region. The Norwegian Earth System Model (NorESM) is used to investigate the surface temperature response distribution resulting from sulphur dioxide (SO2) emission perturbations in four different regions with historically high aerosol emissions: Europe, North America, East Asia and South Asia. Emission perturbations are here defined in relation to the year 2000 emissions provided for the Coupled Model Intercomparison Project phase 5. It is found that the global mean temperature change per unit SO2 emission is similar for all four regions when emissions are increased. When anthropogenic SO2 over Europe is removed, on the other hand, the global temperature change per unit SO2 emission is approximately twice of that obtained in the simulations where SO2 emissions were increased. Thus, the climate sensitivity to European SO2 emissions depends on the magnitude of the emission perturbation in NorESM. The results from the model simulations are used to construct regional temperature potential coefficients (RTPs), which directly link regional aerosol or aerosol precursor emissions to the temperature response in different regions. These RTPs can provide a simplified way to perform an initial evaluation of climate impacts of e.g. different emission policy pathways and pollution abatement strategies.

Li Ying

Monitoring world atmosphere aerosol and Siberia wildfire in 2012 using satellite and model datasets

Ying Li, Yong Xue, Jie Guang, Linlu Mei

key words: Atmosphere aerosol depth, MODIS dataset, NAAPS dataset, ECMWF dataset, Wildfire

Aerosol have extensive impact on earth's climate and environment [1, 2, 3]. Natural (wildfire, dust) and anthropogenic reasons (biomass burning smoke) can change the property of atmosphere aerosols [4]. In order to estimate the concentration, distribution and other properties of aerosols, aerosol optical depth (AOD) derived by satellite and model datasets are widely used in many studies [5, 6]. The Moderate Resolution Imaging Spectroradiometer (MODIS) land Dark Target (DT) AOD are more reliable on the dark surface (ocean, forest) [7]. While, the Synergetic Retrieval of Aerosol Properties algorithm (SRAP) developed based on the synergetic use of the MODIS TERRA and AQUA data can solve aerosol retrieval problem over heterogeneous bright land surface[8, 9]. Otherwise, ECMWF (European Centre for Medium-Range Weather Forecasts) and NAAPS (Navy Aerosol Analysis and Prediction System) the global multi-component aerosol analysis and modeling capability combined the current and expected satellite data streams with other available data also simulate and predict the global aerosol [10]. In this paper, we use MODIS AOD, SRAP AOD, NAAPS SMOKE AOD, and ECMWF ANG (aerosol Ångström exponent) derived from satellite and model datasets to monitoring the world aerosol distribution. The mainly aerosol type of high AOD area (Siberia, Southeast China, Brazil, Sahara Desert, Congo, etc.) is smoke and the main pollution is coarse particles. Then we analyze the Siberia wildfire in June 2012. The NAAPS smoke AOD can reveal the distribution of aerosol that was covered by cloud. The MODIS DT and SRAP average AOD in our study area have the same trend that increased from June 1 to 25 and then declined. And SRAP AOD is a little higher than MODIS DT AOD. Besides the ECMWF reanalysis PM2.5 is increased with AOD and showed good correlation with it, which indicate that this wildfire has serious impact on aerosol and air quality.

Li Zhanqing

Air Pollution and Climate Changes in China: Impact and Feedback

Zhanqing Li

key words: aerosol, climate

Aerosol can affect the atmospheric processes in numerous ways by altering many components of the energy and water cycles such as the PBL, atmospheric thermodynamics, cloud microphysics and morphology, atmospheric circulation, etc. While many mechanisms have been proposed under certain constrained conditions, it has been a daunting task to identify, understand and quantify the various effects. However, substantial and fast progresses in all the fronts have been made in the last decade or so. Increasing evidences have emerged showing the effects of aerosol on both the climate system and day to day weather are so significant that warrant consideration and accounting for in GCMs and NWPs. I will summarize some of our studies in these broad fronts, followed by more dedicated investigations concerning the impact of air pollution on climate changes in China. Few places are more ideal than China to unravel the complex relationships between weather/climate and aerosol whose loading is strong and types are diverse with strong long-term trends. I will give a brief overview of the major findings we have got over a decade of collaborative studies in China, especially following some major field experiments such as EAST-AIRE (2005), ARM Mobile Facility Deployment in China (2008), EAST-AIRc (2010), EAST-AIRcp (2013-2015), and the ongoing air & ground campaigns right now in Hebei.

Liao

Climatic effects of aerosols in China constrained by nationwide measurements

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Accurate representation of concentrations and optical properties of aerosols in climate models are essential for simulations of climatic effects of aerosols. To reduce uncertainties associated with the estimates of climatic effects of aerosols, Chinese Academy of Sciences launched two observational networks in 2011 to carry out continuous measurements of speciated size-resolved aerosol concentrations and aerosol optical properties nationwide in China. We use the measurements from these two networks as well as those from the China Meteorological Administration (CMA) Atmosphere Watch Network (CAWNET) and the AErosol RObotic NETwork (AERONET) to constrain the simulated climatic effects of aerosols in China. We find that current climate models generally underestimate the impacts of all major aerosol species in China on climate change. The NCAR-CESM model is used to quantify how the low biases in simulated aerosol concentrations and aerosol optical depth in China influence aerosol radiative forcing and the associated climate responses regionally and globally.

Lin

Comparison of dust cycle simulated by CESM with two different dust emission schemes

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Dust aerosol is one of the main aerosol types in the atmosphere that impacts the earth environment and the climate system. Currently dust cycle has been implemented into the climate models and the Earth System Models. However, there are still large uncertainties in the models' representation of dust emission processes. Therefore, it is desirable to embed multiple dust emission schemes within the same model framework to understand the bias in dust simulation and model's sensitivity. In this study, we first implement a physically-based dust emission scheme developed by Shao (2004) into the Community Earth System Model (CESM). Then simulations of a typical dust storm during 19-22 March 2010 over East Asia with this scheme (hereafter Shao04 scheme) and the original scheme (following Zender et al. [2003], hereafter Zender03 scheme) are conducted. Simulation results are compared against observed dust events and surface PM10 concentrations. Generally CESM with either scheme captures well the main dust emission regions. However, Shao04 scheme simulates better the temporal and spatial evolution of surface dust concentrations than Zender03 scheme. This may be ascribed to the underestimation of threshold friction velocity and the deficiency of soil erodibility in Zender03 scheme. The model is further used to simulate the global dust cycle for the period of 1981-2005. The simulations are evaluated with various observations including surface visibility, surface dust concentration, dust deposition flux, and aerosol optical depth. The results show that CESM with either scheme reproduces well the main dust plumes globally. Moreover, Shao04 scheme simulates 10% larger dust emission and larger mass fraction for small particles (0.1-1 μm) than Zender03 scheme. Correspondingly, global mean dust burden and dust optical depth simulated by Shao04 scheme are 17% and 29% larger respectively. Overall, remarkable difference in dust distribution is found in North Africa, Central Asia and South Asia.

Lipponen

Pixel level uncertainty estimates for AOD using Bayesian Dark Target algorithm
Antti Lipponen, Tero Mielonen, Mikko Pitkänen, Robert Levy, Virginia Sawyer, Sami Romakkaniemi, Ville Kolehmainen, Antti Arola

key words: AOD retrieval, Dark Target, MODIS, Uncertainty quantification

We have developed a Bayesian inversion algorithm for the MODIS Dark Target aerosol optical depth (AOD) retrieval. In our inversion algorithm, we use a modified surface reflectance relationship to improve the accuracy of the AOD retrieval, and utilize statistical prior models for AOD to incorporate spatial correlation information and AOD seasonality into the retrieval. The solution of the Bayesian inverse problem is the probability distribution of AOD given the reflectances observed by the MODIS instrument and it therefore allows for uncertainty quantification for the retrieved AOD at a pixel level. We test the inversion algorithm with MODIS data from several regions of different aerosol characteristics and show that the use of the Bayesian Dark Target algorithm significantly improves both the accuracy and precision of the AOD retrievals in most of the regions. The main reason for the improved performance is the modified surface reflectance relationship. Furthermore, we evaluate the reliability of the pixel level uncertainties in our retrieval and compare them with the standard MODIS AOD uncertainty.

Liu

Dust vertical and horizontal distributions simulated by CESM and compared with Calipso observations

Xiaohong Liu, Mingxuan Wu, Tao Luo, Chenglai Wu, Zhien Wang, Chun Zhao

key words: dust, climate

In this study we investigate the atmospheric processes affecting the horizontal and vertical transport of soil dust, with a focused region from Asia sources to North America. The NCAR CESM model simulated dust plumes are validated with the Calipso observed dust extinction. Sensitivity tests of CESM model are conducted to examine the important processes responsible for the large discrepancies between modeled and observed dust extinction profiles, which include dust emission, dust size distribution, and gravitational settling.

Liu Hongqing

NOAA VIIRS Dark Target-Bright Surface Aerosol Optical Depth Algorithm

Hongqing Liu, Hai Zhang, Istvan Laszlo, Shobha Kondragunta, Lorraine Remer, Pubu Ciren, Jingfeng Huang, Stephen Superczynski

key words: Aerosol, VIIRS

A new algorithm to retrieve Aerosol Optical Depth (AOD) over both dark and bright land surfaces is developed at NOAA/NESDIS. This algorithm has not only a new retrieval approach but is also designed to run on both Visible Infrared Imaging Radiometer Suite (VIIRS) and GOES-R Advanced Baseline Imager (ABI) data to achieve a cross-platform consistency of NOAA satellite-based aerosol retrievals. Compared to the current operational VIIRS algorithm, this algorithm has extended the spatial coverage (includes bright land surface and inland lakes) and measurement range (from -0.05 to 5.0) of retrieved AOD; more stringent internal tests and quality control for detecting unfavorable retrieval conditions; and updated aerosol models that account for the non-spherical shape of dust and are consistent with the ones used in the MODIS algorithm. For retrieval over land, surface spectral reflectance relationships are developed on a gridded basis (0.1°) for bright surfaces, while those for dark targets are established in a general formulation as functions of surface greenness, redness and observation geometry. A hybrid approach is adopted to merge the current VIIRS-like and MODIS-like approaches to achieve an optimal combination of the advantages over low and high AOD retrievals respectively. As a proof of concept, the new AOD algorithm (to be implemented in the NOAA Enterprise Processing System of the Joint Polar Satellite System) is run with VIIRS data over an extended time period to evaluate its performance against AERONET measurements, current operational VIIRS retrievals and the latest MODIS Collection 6 aerosol products. Preliminary results show increased spatial coverage, capturing of high AODs during exceptional events, and improved performance.

Liu Hongyu

Constraints From Airborne 210 Pb Observations on Aerosol Scavenging and Lifetime in a Global Chemical Transport Model

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key words: tracer studies, aerosol lifetime, aerosol lifetime, wet removal, radionuclide, CTM

Cloud (in-cloud and below-cloud) scavenging is the dominant loss process for a whole suite of tropospheric aerosols and largely determines their burden, distribution, and lifetime. Its parameterization in current global models has been identified by the IPCC AR5 as a major source contributing to uncertainties in model estimated aerosol radiative forcing. The atmospheric radionuclide, 210 Pb (radioactive half-life of 22.3 years), has long been recognized as an excellent tracer for studying cloud scavenging of aerosols. 210 Pb is produced in the atmosphere by radioactive decay of land-emitted gaseous 222 Rn, and indiscriminately attaches to ambient submicron aerosols. In a previous study with the GEOS-Chem chemical transport model, the global lifetime of tropospheric 210 Pb aerosol was estimated to be ~9 days. More recently, modifications (e.g., scavenging in mixed-phase cloud) have been made to the aerosol scavenging parameterization in the model. However, the model tropospheric 210 Pb lifetime has not been examined comprehensively in terms of its sensitivity to the updated scavenging parameterization and constraints from observations. In this study, we use the NASA airborne 210 Pb data collected over the past two decades or so to constrain cloud scavenging of aerosols in GEOS-Chem. Those data cover four continents and two oceans, allowing us to obtain a global tropospheric 210 Pb aerosol lifetime constrained by observations from different regions and altitudes. By comparing with observations, we are also able to assess the performance and impacts of the updated cloud scavenging in various regimes (e.g., tropics, Polar Regions, and upper troposphere). Initial results indicate that the global tropospheric 210 Pb aerosol lifetime can vary from 5.3 to 8.8 days depending on whether or not in-cloud scavenging by snow, in-cloud impaction scavenging, and temperature-dependent cloud water content are included in the model. We find that inclusion of scavenging in mixed-phase and ice clouds significantly improves simulated 210 Pb in the upper troposphere.

Ma Qiao

Influence of NO2 on secondary organic aerosol formation from ozonolysis of limonene

Qiao Ma, Changjin Hu, Zhi Liu, Yue Cheng, Nana Wei, Yanbo Gai, Xiaoxiao Liu, Xuejun Gu, Weixiong Zhao, Mingqiang Huang, Zhenya Wang, Weijun Zhang

key words: limonene, SOA, MCM

Considering the strong tendency of ozonolysis of limonene to form secondary organic aerosol (SOA) in the atmosphere and in indoor environments, impact of NO2 on SOA formation from ozonolysis of limonene has been evaluated using chamber experiments and Master Chemical Mechanism(MCM) coupled with gas-particle partitioning model in this work. A series of 21 smog chamber experiments were performed with or without the presence of NO2 under different [O3]0/[VOC]0 ratios, which were compared comprehensively with the model simulations. The good consistency on the SOA yields has been acquired between the experimental observations and model simulations under different conditions, and it shows that NO2 effect on the SOA formation yields from limonene ozonolysis is entangled with the initial [O3]/[VOC] ratio. When [O3]0/[VOC]0 > 1, the introduction of NO2 will result in an increase of SOA yield under the range of NO2 chosen in this work; while under the [O3]0/[VOC]0 ≤ 1 conditions, the introduction of NO2 will lead to a more complicated changing of SOA yield. Analysis of the aerosol chemical composition with FTIR and model confirmed further that the formations of peroxy acyl nitrates (PANs) and organic nitrates play important roles in aerosol particle formation from limonene ozonolysis, and NO3 chemistry also cannot be neglectable under high NO2 levels. The findings in this work indicate that there is a need to assess NO2 influence on the SOA formation in polluted air.

Ma Po-Lun

Satellite simulators reconcile modeled and observed aerosol effects on clouds

Po-Lun Ma, Philip Rasch, Helene Chepfer, David Winker, Steven Ghan

key words: Satellite simulator, Aerosol indirect effects

In spite of decades of research, aerosol effects on clouds are still a major source of uncertainty in climate projections. Satellite retrievals are an important source for observationally based estimates of aerosol effects, and discrepancies between model and satellite estimates have led the climate modeling community to be concerned that clouds simulated from global climate models are overly sensitive to aerosol changes. This disagreement has driven modelers to change model formulations to increase agreement. To reconcile modeled and observed aerosol indirect effects, we have recently developed an “aerosol lidar simulator” that uses consistent definitions of aerosols and considers only the portion of the atmosphere sounded by the CALIPSO satellite. For the first time to our knowledge, a common algorithm is used in a global climate model and satellite observations to facilitate a consistent comparison of aerosol effects on clouds. We show that when the model and Earth are viewed through the same lens, discrepancies are greatly reduced because retrieved cloud reflectivity and lifetime are significantly less sensitive to aerosols than the real sensitivity. This study indicates that modeled aerosol-cloud interactions may be much closer to satellite-based estimates than commonly perceived, but the estimate may be significantly biased compared to the true situation, and suggests that traditional model evaluation without simulators could drive model development in the wrong direction. We highlight the importance of a common framework between climate models and real world when assessing aerosol indirect effects and calibrating aerosol and cloud processes in climate models, and report the progress on forming a model inter-comparison activity.

Ma Xiaoyan

Aerosol forcing under cloudy sky: estimations from both satellite retrievals and global modeling

Xiaoyan Ma, Fangqun Yu, Johannes Quaas

key words: aerosol forcing, cloudy sky, satellite retrieval, global modeling

According to previous studies, the aerosol radiative forcing derived from global modeling differs substantially with satellite-based calculations. In this study, we estimated cloudy-sky aerosol radiative forcings by employing latest satellite retrievals from 2004 to 2011 in combination with the anthropogenic aerosol optical depth (AOD) fraction obtained from model simulations using the Goddard Earth Observing System-Chemistry-Advanced Particle Microphysics (GEOS-Chem-APM). Our derived annual mean aerosol cloudy-sky forcing (-0.34 W m-2) is higher than the corresponding results (-0.2W m-2) reported in Quaas2008. This study indicates that the derived forcings are sensitive to the anthropogenic AOD fraction and its spatial distribution but insensitive to the temporal resolution used to obtain the regression coefficients, i.e., monthly or seasonal based. The forcing efficiency (i.e., the magnitude per anthropogenic AOD) of this study (11 W m-2) is more than a factor of 2 larger than Quaas2008’s value of 4.7 W m-2. Uncertainties studies suggest that anthropogenic fraction of AOD strongly affects the computed forcings while using aerosol index instead of AOD from satellite data as aerosol proxy does not appear to cause any significant differences in regression slopes and derived forcings.

Evaluations of seasonal and spatial variations of global aerosol optical depth in GEOS-Chem-APM based on multiple-platform observations

Xiaoyan Ma, Fangqun Yu

key words: AOD, GEOS-Chem-APM, satellite, AERONET

Recent AeroCom phase II experiments showed a large diversity in aerosol optical depth (AOD) among 16 detailed global aerosol models, which contributes to the large uncertainty in the predicted aerosol radiative forcing. The GEOS-Chem-APM, a global size-resolved aerosol model, can be considered as a representative AeroCom II model. In this study, multi-year AOD data (2004-2012) from ground-based AERONET measurements and MODIS, MISR and SeaWiFS satellite retrievals are used to evaluate the performance of GEOS-Chem-APM in capturing observed seasonal and spatial AOD variations. Compared to the observations, the modeled AOD is overall good over land, but quite low over ocean possibly due to low sea salt emission in the model and/or higher AOD in satellite retrievals, specifically MODIS and MISR. The modeled AOD over 133 AERONET sites having at least 36 months data available gives a much close magnitude, suggesting that the model is able to reproduce the observed AOD in these sites. Comparisons in various representative regions show that the model overall agrees well in the major anthropogenic emission regions, such as Europe, East Asia and North America. Relative to the observations, the modeled AOD is systematically lower in biomass burning regions such as South Africa and South America possibly due to uncertainties in emission inventory, but slightly higher in North Africa likely associated with stronger dust emissions in the model. The model is able to capture the realistic seasonal cycle in all regions, including the peak of AOD in major dust events months and biomass burning seasons. The simulated inter-annual variability is overall consistent with the observations, which is distinctly shown in South Africa and South America with strong inter-annual variability compared to other regions.

Mattoo

Aerosol absorption retrievals from the PACE broad spectrum Ocean Color Instrument (OCI)

Shana Mattoo

key words: PACE, OCI

The PACE (Pre- Aerosol, Clouds and ocean Ecosystem) mission, anticipated for launch in the early 2020s is designed to characterize oceanic and atmospheric properties. The primary instrument on-board will be a moderate resolution (~1 km nadir) radiometer, called the Ocean Color Instrument (OCI). OCI's main purpose will be to enhance current science in aquatic biogeochemistry by offering greater capability than either MODIS or SeaWiFS. To do so, OCI will provide high spectral resolution (5 nm) from the UV to NIR (350 – 800 nm), with additional spectral bands in the NIR and SWIR to support atmospheric correction. Supplementary instruments, such as a multi-angle imaging polarimeter are also being discussed, and these supplementary instruments are associated with the atmospheric objectives of the mission, although they may also offer important new measurements for oceanic objectives. However, the OCI itself is an excellent instrument for atmospheric objectives, providing measurements across a broad spectral range that in essence combines the capabilities of MODIS and OMI, but with the UV channels from OMI to be available at moderate resolution. In preparation for the PACE mission we have begun the theoretical work necessary to create a robust, operational aerosol retrieval for OCI. This retrieval is based on the MODIS Dark Target aerosol retrieval over ocean that returns aerosol optical depth and an estimate of aerosol size distribution. It then uses these retrieved parameters to constrain a retrieval of aerosol absorption in the UV, using the OCI UV channels. The algorithm is described and its sensitivity to retrieval assumptions is tested. The goal is to understand the limitations

of such an algorithm and under what conditions could we expect to obtain quantitative aerosol absorption information from OCI on PACE.

Mei

Aerosol retrievals over Polar Regions

Linlu Mei, Vladimir ROZANOV, Marco VOUNTAS, Yong XUE, John BURROWS

key words: AOD, Arctic, Satellite

Recent research (e.g., Shindell and Faluvegi, 2009) highlights the alarming climate response to the regional radiative forcing in the Arctic, associated with aerosol from anthropogenic pollution and biomass burning in troposphere and volcanic eruptions in upper troposphere or stratosphere. Although there are almost no large sources of pollution or biomass burning within the Arctic, long-range transport from high to mid-latitudes is responsible for the regular injection of particles into the Arctic atmosphere (Rahn et al., 1977). The impact of anthropogenic activity, natural phenomena on climate in the Arctic is inadequately measured or understood and requires accurate assessment. The importance of aerosol optical properties in the Arctic climate such as that accurate knowledge of Aerosol Optical Thickness (AOT) is required. Some newly developments of aerosol retrieval from satellite instruments over Polar Regions are presented here (Mei et al., 2013; Istomina et al., 2011). The main idea of the retrieval approach is to use the dual-view capability (e.g. AATSR instrument) to separate the contributions due to reflections by atmospheric aerosol and by the underlying surface to the total reflectance measured at the top of the atmosphere (TOA). The algorithm uses an analytical snow BRDF model for estimation of the ratio of the snow reflectances in the nadir and forward views. The aerosol types are obtained by campaign measurements. Then the AOD can be obtained using a Look-Up-Table (LUT) method. The comparison between satellite-derived AOD and in-situ measurements shows promising result. Some Arctic haze events are also analyzed based on the satellite-derived AOD.

Michou

Improvement of the representation of sea salt aerosols in CNRM-CM and CNRM-RCSM

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Key words : modeling, sea-salt, parameterization

This poster presents improvements in the aerosol scheme (Michou et al. 2015, Nabat et al., 2015) of the CNRM climate models, both the CNRM-CM (Coupled Model) global model used in particular in CMIP type simulations and the CNRM-RCSM (Regional Climate System Model) that runs over regional domains with a 3 times finer horizontal grid. We focus here on the representation of sea salt aerosols. The choice of the so-called G13T source function of Grythe et al., 2014 (page 1286 eq. 7), with dependence of fluxes on surface winds and SST, in replacement of the parametrization of Guelle et al., 2001 and Schulz et al., 2004, causes striking differences in emissions, and thus notable differences in AOD and resulting radiative fluxes. The simulation with the new sea salt parameterization is closer to observations both for the AOD, the CRE and the clear-sky radiative fluxes. Growth of particles with humidity (Gerber et al., 1985 eq. 15)-as well as the impact of gust winds have been tested in both models, and conclusions are-presented.

Molanezhad

Studying the Concentration of Urban Air Pollutants under Different Synoptic Conditions, Case Study: Tehran

Mahmood Molanezhad, Mojtaba Mahdian Mahforouzi

key words: Air Pollution, Synoptic Condition, Pressure Patterns, Tehran

Urban Air Pollution is one of the consequences of the Industrial. The megacity of Tehran, with a daytime population of over 8 million, is one of the most polluted cities of the world due to the high concentration of population, installation of factories and industrial complexes in and around the city, high transit of vehicles, high usage of fossil fuels, especial geographical location, exceptional climate, and unique topography. As the behavior of the pollutants is highly dependent on the synoptic pattern of the climate, different synoptic conditions could either strengthen or weaken the concentration of pollutants. Hence, the pollutants behave differently in hourly, diurnal, and seasonal patterns. The main aim of this study is to investigate the concentration of the six main air pollutants (Carbone Monoxide, Nitrogen Dioxide, Tropospheric Ozone, Particulate Matter (PM-10 and PM-2.5), and Sulfur Dioxide) in different synoptic conditions. To achieve the aim, a combined method was used based on a ten years data series using statistical and synoptic method. The pollutant data was gained from Air Quality Control Center (AQCC) and the Department of Environment (DOE) of Tehran. The synoptic conditions were divided into four conditions based on 500 HPa maps: Stable, Unstable, Parallel and Meridian. The synoptic data were obtained from US National Center for Atmospheric Research (NCEP). Then, the average concentration of each pollutant was calculated under different synoptic conditions. The results show that although no significant correlation were found between surface air pressure and pollutant concentrations, all pollutant concentrations were minima under unstable conditions and were maxima under the stable conditions. Also, the pollutant concentrations in parallel and meridian conditions were intermediate.

Mollard

Multiple observational constraints on carbonaceous aerosol absorption in the Hadley Centre climate model

James Mollard, Nicolas Bellouin, Ellie Highwood, Ben Johnson

key words: Carbonaceous Aerosol, AERONET, Aerosol Absorption, HadGEM3

Carbonaceous aerosols play a key role in absorption and scattering of radiation. The latest IPCC reports estimates the uncertainty of the radiative forcing of carbonaceous aerosol to be 1 W m−2. Climate models often distinguish between a strongly absorbing carbonaceous aerosol called black carbon, and a scattering component called organic carbon. Recent studies have suggested that a third type, brown carbon, also exists in the atmosphere and needs to be considered independently. In the past, underestimation of aerosol absorption in models compared to AERONET was addressed by increasing black carbon emissions. However, AERONET samples Absorbing Aerosol Optical Depth (AAOD) incompletely because of difficulties in the remote sensing of aerosol absorption, meaning that a direct comparison can lead to erroneous conclusions. In this talk, we take advantage of AERONET's incomplete sampling to characterize absorption of larger aerosol events, which we show are of uniform composition in a given region. Comparing modelled and retrieved single-scattering albedo and

Angstrom exponent therefore becomes an effective method for identifying and understanding differences. Applying the method to the Hadley Centre climate model, we demonstrate that black carbon emissions are not the only way to improve the comparison of absorption with AERONET. Other levers include organic carbon emissions, black and organic carbon refractive indices, black and organic carbon densities, and hygroscopic growth curves. In this talk, we describe how to combine multiple constraints, in addition to AERONET, to choose which combination of levers is most beneficial to the model in a given region.

Muelmenstaedt

Satellite-derived warm rain fraction as a constraint on the cloud lifetime effect

Johannes Muelmenstaedt, Gunnar Myhre, Minghuai Wang, Shipeng Zhang, Philip Stier, Piers Forster, Toshihiko Takemura, Stefan Kinne, Annica Ekman, Johannes Quaas

key words: aerosol-cloud-precipitation interactions, effective radiative forcing, warm rain,satellite retrievals, general circulation models

We present a global climatology of warm-rain occurrence fraction derived from CALIPSO-CloudSat satellite observations. (Warm rain is defined as liquid precipitation at the surface originating from pure liquid-water clouds.). This climatology shows that warm rain is rare over land compared to ocean, especially in the extratropics. In a subset of AeroCom models, we can diagnose the warm-rain fraction and compare it to the satellite climatology. We find that the modeled land--sea contrast is smaller and the warm-rain fraction is larger by an order of magnitude in comparison to the satellite data.
The more precipitating warm clouds are simulated in a model, the more opportunity aerosols have to influence the precipitation microphysics, since the aerosol influence is mainly implemented for autoconversion in liquid-water clouds in current models. We hypothesize that the strength of the cloud lifetime effect in models is therefore related to the warm-rain fraction. Our new satellite climatology could provide a powerful constraint on the magnitude of the cloud lifetime effect. We propose to test this hypothesis using Aerocom models. Here we present preliminary results based on a subset of models that sample the intermodel spread in lifetime effect strength.

Myhre

Multi-model simulations of aerosol and ozone radiative forcing for the period 1990-2015

Gunnar Myhre

key words: Trend in aerosols, Radiative forcing of aerosols

Over the past decades, the geographical distribution of emissions of substances that alter the atmospheric energy balance has changed due to economic growth and pollution regulations. Here, we show the resulting changes to aerosol and ozone abundances and their radiative forcing, using recently updated emission data for the period 1990-2015, as simulated by seven global atmospheric composition models. The models broadly reproduce the large-scale changes in surface aerosol and ozone based on observations (e.g., -1 to -3%/yr in aerosols over US and Europe). The global mean radiative forcing due to ozone and aerosols changes over the 1990-2015 period increased by about +0.2 Wm-2, with approximately 1/3 due to ozone. This increase is stronger positive than reported in IPCC AR5. The main reason for the increased positive radiative forcing of aerosols over this period is

the substantial reduction of global mean SO2 emissions which is stronger in the new emission inventory compared to the IPCC, and higher black carbon emissions.

Nobre

Radiation fluxes in the Brazilian Global Atmospheric Model using CLIRAD and RRTMG radiation schemes

Paulo Nobre, Débora Alvim, Diego Enoré, Silvio Figueroa, Josiane Silva, Paulo Kubota, Vinicius Capistrano

key words: Brazilian Global Atmospheric Model, CLIRAD-SW, RRTMG, Radiation schemes

The Center for Weather Forecasting and Climate Studies - CPTEC / INPE has developed the Brazilian Global Atmospheric Model (BAM) to improve the quality of weather and climate prediction. BAM is the atmospheric component of Brazilian Earth System Model (BESM) that is coupled to the oceanic component (MOM4p1) through GFDL/FMS coupler. BAM includes two radiation schemes – CLIRAD-SW and RRTMG. While the shortwave of the NASA's CLIRAD has been improved by incorporating new gaseous absorption parameterizations and is validated in climate simulations, a new short and long-wave radiation scheme, the Rapid Radiative Transfer Model for GCMs (RRTMG), has been recently implemented in BAM. In CLIRAD-SW, the magnitude of absorption coefficients in each homogeneous layer depends on both species concentrations in the layer and species amounts accumulated along the direct solar radiation path from the top of the atmosphere (TOA). The number of the k-distribution terms varies from 1 to 4 in each of the eight bands. The total number of pseudomonochromatic intervals in the new version of the code is 15. The RRTM_SW and RRTM_LW calculate fluxes and heating rates for the shortwave (14 bands, from 0.2 μm to 12.2 μm) and longwave (16 bands, from 3.1 μm to 1.0 mm). Accurate radiative fluxes calculations are critical to accurate simulations of climate and weather in GCMs. This study compares radiative fluxes in BAM using two different solar radiative transfer schemes – CLIRAD-SW and RRTMG with observed data.

Noroozi

Identify areas with dust storm potential of physiographic and climatic characteristics

Ali Akbar Noroozi

key words: Dust storm, BTD, AOD images

Dust storm is one of the most important consequences of wind erosion in Iran and the world, particularly in the West and South West of the Iran. This study have been completed by aim of identify areas of potential dust storm generation in the Khuzestan province. For this purpose, a combination of statistical methods, remote sensing and modeling were used. The data used included: daily synoptic stations, Landsat and MODIS daily satellite images, U and V data from the NOAA Web site and landuse changes over the period 2000-2015.The results of the daily data processing codes of dust showed that in the annual time scale, the most frequent occurrence of dust have been recorded during 2008 and 2009. In the seasonal scale, late of spring and early summer and in monthly scale May, June and July are the largest dust storms events. Hourly scale, the highest occurrence of the dust at 15:30 pm local time (12 GMT) was recorded. Detection of dust storm on satellite imagery and their concentration using images obtained from AOD and BTD indices, represent the largest concentration of dust in the West and South West regions of Khuzestan province, where more than 80 percent of the

dust in these areas were consistent with the results of statistical data. Trace Route dust entering the province using backward trajectory techniques and speed and wind direction maps showed that during the warm period of the year the most dust input is from northwest - southeast and west -East and in the cold period from South - to the north. Landuse Mapping and evaluation of its changes during the period 2000-2015 in the seasonal scale showed that a decrease in the irrigated areas, vegetation (30 percent) and increasing soil barren lands in 2015, especially for the western half of Khuzestan.
Physiographic features such as susceptibility, salty and swampy soil, low soil moisture, changes in land uses indicative of areas prone to the potential for dust to the West and the southern province. Hence, it influences the decision-making and planning necessary to prevent escalation of this phenomenon in various organizations and if possible confront the event that more should be done to areas of the western and southern provinces (of Iran).

Nwofor

Aerosol loading in the Nigerian sub-Sahel; analytical deductions from AERONET data

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key words: AERONET, AOD and FMF temporal change, sub-Sahel, Nigeria, Dust

This paper reports analyses of key aerosol optical parameters from the National Aeronautics and Space Administration (NASA) AErosol Robotic Network (AERONET) data of Ilorin, a desert encroachment location in Nigeria's sub-Sahel (8^o 32'N; 4^0 34'E). It consists of a quasi-stationary trend representation of the seasonality of the Aerosol Optical Depth (AOD) and mono-modal and bi-modal representations respectively of the wet and dry season Angstrom Exponents (AE) as well as curvature analyses of the seasonal AE. From the results, it is deduced that short-term changes in the form of strong seasonal and weak inter-annual cycles are found to be driven by meteorological factors namely rainfall and wind. From AE analyses, the coarse aerosol fraction (from advected and locally lifted dust) continues to dominate the fine fraction (from biomass burning and other combustion products), but with both fractions increasing significantly in the dry period over the last decade, possibly due to intensifying desertification and aridity of the surface (which potentially influence local dust lifting) as well from the carbonaceous particles (arising from increased urbanization and industrialization of surrounding localities). Analytical relations linking the dry-season bi-modal fractions to the total optical depth (AOD_T) which can be useful in deducing relative sensitivities of the AOD_T to the modes are presented.

Onyenekwe

Pollutants in three area councils of the federal capital territory, Nigeria

Pius Ikoko, Paul C Onyenekwe

key words: pollution, Abuja

There is need, in Sub-Saharan Africa (SSA) for proper air quality management and data on the actual impact of air quality on health. Abuja Nigeria, a rapidly developing city in Sub-Saharan Africa, presents a unique opportunity to investigate the impact of air and noise pollution. The air quality (sulphur dioxide, nitrogen dioxide nitrogen monoxide carbon monoxide, carbon dioxide) and noise in three area councils of the FCT were studied. The vehicular emissions are a significant contributor to ambient pollution, especially in urban areas. It was observed that the average air qualities were still within the acceptable level set by the National Environmental Standard and Regulation (NESREA). However, there was a high level of these gases in the Area Councils sampled (P.0<0.05). In Kuje Area Council (sulphur dioxide in Kye market 0.2ppm, Chibiri village 0.2ppm, Nitrogen dioxide in Kiyi Village 0.1ppm Kye market 0.1ppm and noise in Kye market 102dB. In Gwagwalada Area Council Nitrogen monoxide in SDP junction 0.5ppm, Zuba 0.4ppm, sulphur dioxide in main market 0.2ppm and Zuba 0.1ppm and high level of noise in Zuba 103dB, main market 95.6dB and SDP junction. In Abuja Municipal Council, there was high level of sulphur dioxide in Nyanya 0.2ppm, Mpape 0.3ppm, Nitrogen dioxide Lugbe 0.1ppm, Mpape 0.2ppm when it was subjected to a single analysis of variance (ANOVA). This was attributed to the fact that wood burning, kerosene heater, un-vented gas stove and environmental tobacco smoke, old and used cars, commercial buses, trucks that are above 15 years old, that are imported, motor cycles, and power generating set are responsible for the high level of gases.

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Pu

The impact of Pacific Decadal Oscillation on springtime dust activity in Syria

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key words: dust, MODIS, Arabian peninsula

The increasing trend of aerosol optical depth in the Middle East and a recent severe dust storm in Syria have raised questions as whether dust storms will increase and promoted investigations on the dust activities driven by the natural climate variability underlying the ongoing human perturbations such as the Syrian civil war. This study examined the influences of the Pacific decadal oscillation (PDO) on dust activities in Syria using an innovative dust optical depth (DOD) dataset derived from Moderate Resolution Imaging Spectroradiometer (MODIS) Deep Blue aerosol products. A significantly negative correlation is found between the Syrian DOD and the PDO in spring from 2003-2015. High DOD in spring is associated with lower geopotential height over the Middle East, Europe, and North Africa, accompanied by near surface anomalous westerly winds over the Mediterranean basin and southerly winds over the eastern Arabian Peninsula. These large-scale patterns promote the formation of the cyclones over the Middle East to trigger dust storms and also facilitate the transport of dust from North Africa, Iraq, and Saudi Arabian to Syria, where the transported dust dominates the seasonal mean DOD in spring. A negative PDO not only creates circulation anomalies favorable to high DOD in Syria but also suppresses precipitation in dust source regions over the eastern and southern Arabian Peninsula and northeastern Africa.

Petrenko

AeroCom Biomass Burning Emissions Experiment Phase 1: Fire emission source strength emission factors

Mariya Petrenko, Ralph Kahn, Mian Chin, Maria Val Martin

key words: Biomass burning emissions, smoke emission correction

Biomass burning aerosol emissions are usually input into models from external emissions inventories, which provide information on the location and strength of burning sources. Under- or overestimation of emissions in the inventories can lead to erroneous estimates of simulated aerosol optical depth and aerosol properties. However, model configuration is another significant source of possible biases in smoke aerosol simulation. Previously, we determined a range of emission-factor adjustments to standard source-strength inventories using the GoCart model and AOD snapshots of smoke plumes from MODIS, and noted that for this model, emission factor adjustments were fairly consistent within ecological regions [Petrenko et al., 2012]. In the past year, we have completed a study refining our method of analyzing the smoke AOD from individual plumes. In addition, a number of AeroCom modeling teams ran simulations for the year 2008 using the GFED3 biomass burning inventory multiplied by 0, 0.5, 1, 2, and 5. Simultaneous analysis of this ensemble of runs provides a rich source of information about the biases stemming from both the assumed inventory and differences in the model configurations. We present the reference observational dataset, summarize refinements to the method of using snapshots of satellite aerosol optical depth (AOD) to constrain the models, and discuss initial insights into the model inter-comparison for several global biomass burning regions.

Qaiser

Spatial and temporal variability trend and characteristics of aerosol loading across monsoon zone in Pakistan

Ghazala Qaiser, Azmat Hayat Khan

key words: Aerosol optical depth, Aerosol loading, MODIS Aerosol data, Monsoon Region, Pakistan

Characteristics and trend in quantitatively measured extinction of solar radiation by aerosol scattering and absorption termed as aerosol optical depth (AOD) was studied for eastern parts of country using Moderate Resolution Imaging Spectroradiometer (MODIS) derived aerosol data for 2001-2015 periods. Analysis revealed that aerosols concentration was mainly regulated by topography, land use and economic practices. Increased tendency in AOD was aligned along northeast Punjab having complex topography and heavy aerosol loading was confined to mega cities having congested industrial states. Airborne dust from ground is an important source of coarse mode aerosols and correspond well to arid regions and more significant during pre-monsoon period. Data reveals that the mean higher value of AOD was observed in monsoon and post monsoon period especially in December. High aerosol concentration coupled with low temperatures result in fog formation that has significant economic impacts. The anthropogenic activities led to an increase in fine mode AOD in mega cities. The main aerosol type gradually shifted to the urban industrial type across eastern parts of country due to increased economic activities.

Remer

The NOAA VIIRS aerosol products and air quality applications

Lorraine Remer, Hongqing Liu, Pubu Ciren, Istvan Laszlo, Shobha Kondragunta, Hai Zhang

key words: VIIRS, aerosol retrieval

In 2012 the Suomi-National Polar-orbiting satellite Partnership (S-NPP) satellite launched, carrying the VIsible InfraRed Sensor (VIIRS) into orbit. An aerosol retrieval algorithm to be applied to VIIRS observations was ready for business immediately. This algorithm developed under contract with a private company was based on the MODIS Dark Target aerosol algorithm over ocean (MxD04), and on the algorithm that produced MODIS land surface reflectances, retrieving aerosol as a by-product (MxD09). The aerosol group at NOAA/NESDIS inherited this VIIRS algorithm, evaluated it and made the modifications necessary to meet validation criteria for the products that showed sufficient skill. These products include aerosol optical thickness (AOT) over land and ocean, and aerosol size parameter (Angström exponent) over ocean. There is now more than 3 years of high quality NOAA VIIRS aerosol products available for public use. The aerosol products are available at nominal 6 km and 0.75 km resolution along the orbit paths and at 0.25o resolution in daily global files. In summer 2016 NOAA will release a new algorithm to replace this at-launch inheritance. The second generation algorithm incorporates more of the MODIS Dark Target methodology into the land retrieval and expands coverage to higher AOT and brighter surfaces. In addition, NOAA has developed an aerosol detection algorithm that identifies moderate to heavy aerosol events, differentiating between dust events and smoke events. The classification scheme uses the difference in spectral slope between absorbing aerosols and underlying surfaces, and then the difference in size between smoke and dust. The U.S. air quality community makes good use of this qualitative detection product, but the product is global and can be applied anywhere. This aerosol detection and classification product, along with finer resolution aerosol retrieval products across a broader swath than MODIS can provide, offers new space-based opportunities for air quality applications.

Salzmann

Effects of Aerosol on Global Mean and Indian Summer Monsoon Precipitation Trend during the 20th Century

Marc Salzmann

key words: aerosol hydrological sensitivity, precipitation trends, Indian Summer Monsoon

This presentation addresses the influence of aerosols and greenhouse gases on the global mean precipitation trend and on the precipitation trend in the Indian summer monsoon region. It is shown that global mean precipitation has not increased in spite of global warming due to the effect of aerosol. Furthermore, it is argued that coupled climate model averages should fail to reproduce the observed Indian summer monsoon drying unless the aerosol effect is overestimated. Based on CMIP5 data, the hydrological sensitivity to aerosol cooling is found to be roughly twice as large (3-4% precipitation decrease per kelvin cooling) compared to the hydrological sensitivity to greenhouse gas (GHG) warming (1.5-2% K-1 increase per kelvin warming). Using observed 20th century global warming as a constraint on the CMIP5 models suggests that until recently aerosols have completely offset the global mean precipitation increase caused by GHGs in spite of a net global warming and an associated increase in water vapor concentration. Furthermore, it is shown that the CMIP5 model ensemble average reproduces the observed 1950-2000 Indian summer monsoon drying when the effect of observed mulit-decadal internal variability is taken into account. Key results are summarized from doi 10.1126/sciadv.1501572, 10.1002/2015JD023313, and 10.1002/2014JD021783.

Samset

Aerosols as drivers of precipitation change: A PDRMIP multi-model study

Bjorn H. Samset

key words: PDRMIP, aerosols, precipitation

Precipitation is expected to respond differently to various drivers of anthropogenic climate change. In the Precipitation Driver and Response Model Intercomparison Project (PDRMIP), where ten global climate models have perturbed CO2, CH4, black carbon, sulfate, and solar insolation. This allows us both to compare modeled precipitation response across drivers, and to study modeled diversity in the way aerosols affect precipitation patterns and rates. Here, we give an overview of PDRMIP and our first multi-model results, with emphasis on the black carbon and sulfate experiments. We divide changes to global mean and regional precipitation into fast responses that scale with changes in atmospheric absorption and slow responses scaling with surface temperature change. While the overall features are broadly similar between models, we find significant regional intermodel variability, especially over land. Black carbon stands out as a component that may cause significant model diversity in predicted precipitation change, both in terms of overall results, for hydrological sensitivity, and for climate extremes. Processes linked to atmospheric absorption are less consistently modeled than those linked to top-of-atmosphere radiative forcing. We identify a number of land regions where the model ensemble consistently predicts that fast precipitation responses to climate perturbations dominate over the slow, temperature-driven responses.

Quantifying the semi-direct aerosol effect of black carbon

Bjorn H. Samset, Camilla W. Stjern, Gunnar Myhre

key words: black carbon, semi-direct effect

The semi-direct radiative effect of black carbon (BC) aerosols, where cloud properties are altered due to impacts on atmospheric stability and circulation, is poorly constrained in present climate models. Here, we employ a flux decomposition method recently developed by Ghan et al. to calculate the direct, indirect and semi-direct radiative effects of present day anthropogenic BC emissions in two related climate models of differing complexity, using the same atmospheric aerosol distribution. Our aim is to quantify the precision with which we can expect to constrain the semi-direct effect for a given perturbation to BC concentrations. We find that due to internal climate variability, multiple decades of model simulations are required to determine a statistically significant semi-direct effect, even when using strong perturbations in a model setup with fixed sea-surface temperatures. We further show and compare the diagnosed uncertainty due to natural variability to that found when applying a simplified, newly developed radiative kernel method. The kernels are also applied to the AeroCom Phase II model ensemble, extracting the variability in direct and semi-direct effects attributable to differences in BC vertical profiles.

Sand

Aerosols at the Poles: An AeroCom Phase II multi-model evaluation

author: Maria Sand, Bjorn Samset

key words: Aerosols, Arctic, Antarctic

Atmospheric aerosols from anthropogenic and natural sources reach the Polar Regions through long-range transport. By scattering and absorbing solar radiation, aerosols perturb the energy balance in the

region and may have played a significant role in recent Arctic warming. Aerosols in Polar regions however, are poorly constrained in present day global climate models. Here we compare aerosol burdens from simulations with 16 global aerosol models from the Aerocom phase II model inter-comparison project with available observations at both Poles. We show that the annual mean multi-model median is not a bad representation of the observations in Arctic, even though the model spread is large. The models tend to underestimate the spring maximum and overestimate the summer/autumn minimum. We also document the geographical distribution and seasonal cycle of aerosol burdens and shortwave anthropogenic direct radiative forcing (DRF) of the total aerosol, and for the individual aerosol species; black carbon (BC), sulfate, and primary organic aerosols from fossil fuel, bio fuel and biomass burning, in addition to dust and sea-salt. A subset of models have also reported nitrate and secondary organic aerosols. The models produce a median annual mean AOD 0.07 in the Arctic and 0.01 the Antarctic. The Arctic modeled annual mean DRF is slightly negative -0.12 Wm-2, dominated by a positive Black Carbon DRF during spring and a negative sulfate DRF during summer. We perform sensitivity experiments with one of the Aerocom models (GISS modelE) to investigate how regional emissions of BC and sulfate and the lifetime of BC influence the Arctic and Antarctic aerosol burdens.

Sayer

Deep Blue aerosol project new developments: VIIRS and beyond

Andrew Sayer

Key words: deep blue, aerosols

The ‘Deep Blue’ family of aerosol data sets covers the Sea-viewing Wide-field-of-view Sensor (SeaWiFS 1997-2010), Moderate Resolution Imaging Spectroradiometer (MODIS) Terra (2000 onwards), MODIS Aqua (2002 onwards), and now Visible Infrared Imaging Radiometer Suite (VIIRS, 2012 onwards). Deep Blue now provides almost a 20-year time series of aerosol data, with multiple years of inter-sensor overlap aiding in assessments of consistency. We present results from the new VIIRS Deep Blue data set, including validation and comparisons to other products. We also illustrate the potential of the new Advanced Himawari Imager (AHI) sensor in geostationary orbit aboard Himawari 8 for aerosol retrievals, greatly improving the temporal frequency of observations and thus facilitating the tracking of aerosols from source to sink.

Schutgens

Remote sensing evaluation of AEROCOM models

Nick Schutgens

key words: aerosol model, remote sensing

We have started a collaborative effort to comprehensively compare AEROCOM models with remote sensing data. Remote sensing data like AOD (Aerosol Optical Depth), AE (Angstrom exponent) and SSA (Single Scattering Albedo) as well as dust AOD from a variety of ground-based networks and satellites will be used to evaluate current state-of-the-art aerosol models and track their development in the near future. Model evaluation with observations is hampered by observational errors and spatio-temporal differences between model and observational datasets. By collocating model data with aggregated observations we will significantly reduce the sampling issues. By evaluating model data against a variety of remote sensing data we hope to assess true model errors in the context of

observational uncertainty. An important part of this work is the restructuring of existing remote sensing data into a homogenized format that allows more efficient and faster comparison to model data. Preliminary results using a subset of the observational and model datasets will be presented at the AEROCOM workshop.

Shahzad

Analyses of Extreme Air Pollution Events over Lahore using Satellite and Ground Based Remote Sensing

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Key words: Aeronet, Aerosols, Angstrom Exponent, AOD,

Extreme events of haze and air pollution are increasing day to day in many big cities of Pakistan due to the rapid urbanization and industrialization. Such events are causing adverse affects on people's health, regional air quality and climate. On the other hand, understanding about the physical and chemical properties of aerosol in such extremely polluted conditions in Pakistan is still sparse. Therefore, it is the first study to analyze the physical and chemical properties of aerosol and its associated meteorological conditions during highly polluted events. We selected an event of extreme air pollution that occurred on October 14-23, 2010, over Lahore, Pakistan. The remote sensing measurements from AERONET, MODIS and MISR are used to characterize the event in terms of aerosol optical depth (AOD), size distribution, complex refractive indices and aerosol fractions. The average aerosol properties and meteorological conditions during the event were also investigated by simulation using the numerical model HYSPLIT. The average AOD is about 2.6 at 500 nm, and the Angstrom exponent is 1.2 from 440 to 675 nm. The fine-mode AOD is 2.5 corresponding to a fine-mode fraction of 0.96. The coarse particles occupied a considerable volume fraction of the bimodal size distribution in winter haze event, with the mean particle radius of 0.2 and 2.8 μm for the fine and coarse modes respectively. The imaginary part of the refractive indices exhibited a relatively flat spectral behavior with an average value of 0.04 from 440 to 1018 nm. The real part showed spectral variation, with the value at 870 nm (about 1.43) higher than the other three wavelengths (about 1.38 at 330 nm). The results of the study set direction for the future studies to understand the aging process of a polluted air mass during such extreme events of air pollution in Pakistan.

She

Joint retrieval of aerosol optical depth and surface reflectance over land using geostationary satellite data

Lu She, Yong Xue, Aojie Di, Jie Guang

key words: AOD retrieval, Himawari-8,Surface BRDF

Atmospheric aerosol is considered to be one of the most important factors that affect global climate and Earth's radiation balance. Retrieval of atmospheric aerosol using satellite data has always been a hot topic in atmospheric research. In the present study we proposed an algorithm to estimate hourly

aerosol optical depth (AOD) and daily land surface bidirectional reflectance using multi-temporal data from the Advanced Himawari Imager (AHI) aboard Himawari-8 geostationary satellite.
The algorithm is based on the assumption that the aerosol properties are temporally variable while the land surface bidirectional reflectance factor (BRF) remain unchanged during a short period of time (a single day). A Radiative Transfer Model is coupled with Ross-Li-sparse BRF model to calculate the AOD and surface reflectance simultaneously. In the inversion, the MODIS bidirectional reflectance distribution product (MCD43) was used as the prior information of the surface reflectance and the single scattering albedo (SSA) and asymmetry factor (g) were derived from predefined aerosol types with different SSA and g factor. We assume one aerosol type within a 50km*50km window. The high resolution AOD and BRF are obtained using an optimal estimation method, furthermore, the proper aerosol model is determined. The retrieved AOD and Angström exponent α were compared with Aerosol Robotic Network (AERONET) measurements, which shows good consistency.

Shedeed

Aerosol–cloud interactions - a challenge for measurements of cloud–climate interactions

Shaymaa Shedeed

key words: Aerosol, Cloud–climate, Rate of precipitation

Research in aerosol properties and cloud characteristics have historically been considered two separate disciplines within the field of atmospheric science. The recent attention paid to global climate change has shown that clouds can have a considerable effect on the Earth's climate and that one of the most uncertain aspects in their formation, persistence, and ultimate dissipation is the role played by aerosols. This highlights the need for researchers in both disciplines to interact more closely than they have in the past. This is the vision behind this focus issue of Environmental Research Letters.
Certain interactions between aerosols and clouds are relatively well studied and understood. For example, it is known that an increase in the aerosol concentration will increase the number of droplets in warm clouds, decrease their average size, reduce the rate of precipitation, and extend the lifetime. Other effects are not as well known. For example, persistent ice super-saturated conditions are observed in the upper troposphere’s that appear to exceed our understanding of the conditions required for cirrus cloud formation. Further, the interplay of dynamics versus effects purely attributed to aerosols remains highly uncertain. The purpose of this focus issue is to consider the current state of knowledge of aerosol/cloud interactions, to define the contemporary uncertainties, and to outline research foci as we strive to better understand the Earth's climate system.
This focus issue brings together laboratory experiments, field data, and model studies. The authors address issues associated with warm liquid water, cold ice, and intermediate temperature mixed-phase clouds. The topics include the uncertainty associated with the effect of black carbon and organics, aerosol types of anthropogenic interest, on droplet and ice formation. Phases of water which have not yet been fully defined, for example cubic ice, are considered.

Shi

Constructing an event based aerosol product under high aerosol loading conditions

Yingxi Shi, Robert Levy, Shana Mattoo, Lorraine Remer

key words: Aerosol, Remote Sensing

High aerosol loading events, such as the Indonesia's forest fire in Fall 2015 or the persistent wintertime haze near Beijing, gain tremendous interests due to their large impact on regional visibility and air quality. Understanding the optical properties of these events and further being able to simulate and predict these events are beneficial. However, it is a great challenge to consistently identify and then retrieve aerosol optical depth (AOD) from passive sensors during heavy aerosol events. Some reasons include:1). large differences between optical properties of high-loading aerosols and those under normal conditions, 2) spectral signals of optically thick aerosols can be mistaken with surface depending on aerosol types, and 3) Extremely optically thick aerosol plumes can also be misidentified as clouds due to its high optical thickness. Thus, even under clear-sky conditions, the global distribution of extreme aerosol events is not well captured in datasets such as the MODIS Dark-Target (M-DT) aerosol product. In our study, we are exploring methods to identify and then retrieve such optically thick aerosol events. Our goal is to create an event based aerosol product that would compensate the standard "global" aerosol retrieval. In addition to adjusting thresholds (cloud mask, inland water identification, and/or snow masks) within M-DT retrievals, we look towards synergy with observations from other sensors.

Shukla

Identification of the cloud base height over the central Himalayan region: Intercomparison of Ceilometer and Doppler Lidar

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key words: Cloud base height, Doppler Lidar, Celiometer, Radiosonde

We present the measurement of cloud base height (CBH) derived from the Doppler Lidar (DL), Ceilometer (CM) and Moderate Resolution Imaging Spectroradiometer (MODIS) satellite over a high altitude station in the central Himalayan region. We analyzed six cases of cloud overpass during the daytime convection period by using the cloud images captured by total sky imager. The occurrence of thick clouds (> 50%) over the site is more frequent than thin clouds (< 40 %). In every case, the CBH indicates less than 1.2 km, AGL observed by both DL and CM instruments. The presence of low level clouds in the height-time variation of signal to noise ratio of DL and backscatter of CM shows a similar diurnal pattern on all the days. Cloud fraction is found to be maximum during the convective period. The CBH estimated by the DL and CM showed reasonably good correlation (R2=0.76). The DL observed updraft fraction and cloud base vertical velocity also shows good correlation (R2=0.66). The inter-comparison between DL and CM will have implications in filling the gap of CBH measurements by the DL, in absence of CM. More deployments of such instruments will be invaluable for the validations of meteorological models over the observationally sparse Indian regions.

Sogacheva

How the different approaches effect the aerosol optical depth retrieved from the (A)ATSR

Larisa Sogacheva, Pekka Kolmonen, Timo H. Virtanen, Gerrit de Leeuw, Gareth E. Thomas, Adam Povey, Roy G. Grainger, Andreas Heckel, Peter North, Jan Greisfeller, Michael Schulz, Stefan Kinne, Thomas Popp, Simon Pinnock

key words: aerosol optical depth, AATSR, algorithms comparison, Aerosol_cci

Within the ESA Climate Change Initiative (CCI) Aerosol_cci (2010–2014) and Aerosol_cci2 (2015-2017) projects, algorithms for the production of long-term total column aerosol optical depth (AOD) datasets from the (Advanced) Along-Track Scanning Radiometer (ATSR-2 on ERS-2 and AATSR on ENVISAT) sensors are continuously improved. However, the AOD and Ångström exponent (AE) retrieved from different algorithms may vary for different regions and some algorithms may perform better than others in different aerosol loading and surface conditions. In the current study, we present the intercomparison of the approaches and results for the ADV/ASV (AATSR Dual/Single View), the Optimal Retrieval of Aerosol and Cloud (ORAC) and Swansea University (SU) algorithms. All three algorithms use the dual view capability, which is the main feature of the ATSR instruments. However, aerosol retrieval approach, cloud screening, aerosol composition and surface treatment are different in those algorithms. In ADV over land algorithm (Kolmonen et al., 2015), the dual view capability is used to effectively eliminate the contribution of the surface reflection to the TOA reflectance, using the k-ratio approach, and retain only the atmospheric path radiance. ORAC is an optimal estimation retrieval scheme designed to provide estimates of aerosol and cloud properties (Thomas et al. 2009). The algorithm retrieves aerosol optical depth, effective radius and the surface reflectance in each shortwave ATSR channel. Over land a surface reflectance parameterisation, similar to that employed by the SU-ATSR land algorithm is utilised, while over the sea, the ocean surface reflectance model of Sayer et al. (2010) is used to provide an a priori surface constraint.The SU-ATSR over land algorithm (North, 2002) employs a parameterised model of the surface angular anisotropy, and uses the dual-view capability of the instrument to allow estimation without a priori assumptions on surface spectral reflectance. Over ocean, the algorithm uses a simple model to exploit the low ocean leaving radiance at red and infra-red channels at both nadir and along-track view angles (Bevan et al., 2012). In order to explain the dissimilarities in the retrieval results, which are seen on the AOD aggregated maps and in the AOD time series, results are investigated for selected cases with different aerosol loading and surface conditions.

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Stanelle

Aerosol component of the global climate-aerosol-chemistry model ECHAM6-HAMMOZ: ECHAM6-HAM2

Tanja Stanelle, Isabelle Bey, Sylvaine Ferrachat, Colombe Siegenthaler-LeDrian, David Neubauer, Declan O'Donnell, Sebastian Rast, Hauke Schmidt, Sabine Schröder, Martin Schultz, Nick Schutgens, Philip Stier, Ulrike Lohmann

Key words: global aerosol climate model, validation

We will present the latest version of the ECHAM-HAMMOZ model family, which assembles the most recent versions of the atmospheric general circulation model ECHAM (namely ECHAM6, as described in Stevens et al., 2013), the aerosol module HAM (based on the HAM2 version as described in Zhang et al., 2012) and the atmospheric trace gas chemistry module MOZ (described in Rast et al., 2014). Since the aerosol (HAM) and the chemistry (MOZ) modules can be used either interactively or in an independent manner, we use the denomination of ECHAM-HAMMOZ when both modules are used, and ECHAM-HAM and ECHAM-MOZ when only the aerosol or chemistry modules are used, respectively. The emphasis of the presentation is placed on the description of the new features in ECHAM6-HAM2 and its validation in terms of aerosol properties with ground-based stations and remote sensing observations. Aerosol-cloud interactions are key to ECHAM-HAM. Aerosols interact with clouds in ECHAM-HAM by acting as cloud condensation and ice nuclei (Stier, 2016; Neubauer et al., 2014). New features in terms of aerosol-cloud interactions include the size-resolved in-cloud scavenging scheme by Croft et al. (2010), orographic cirrus clouds (after Joos et al., 2008), the Abdul-Razzak and Ghan (2002) activation scheme and improvements of several cloud microphysical conversion processes. The impact of some of these changes will be addressed through sensitivity studies.

Air pollution in Southern West Africa: What do different emission inventories tell us?

Tanja Stanelle, Ulrike Lohmann, David Neubauer, Isabelle Bey

key words: aerosol climate modelling, West Africa

Southern West Africa is currently experiencing an unprecedented population growth of 2-3 % per year and an economic growth of approximately 5% per year. This has an impact on land use change and anthropogenic emissions (United Nations Economic Commission for Africa, 2010), which can result in modifications of aerosol concentrations in the air. Aerosols can impact the climate by scattering and absorption of radiation and by acting as cloud condensation and ice nuclei. The quality of emission inventories is very crucial for simulating anthropogenic aerosol concentrations. But for West Africa it turns out that the estimated emission fluxes differ a lot between inventories (e.g. ACCMIP, EDGAR). With our global aerosol-climate model ECHAM6-HAM2 we are able to investigate the feedbacks between aerosol emissions (natural as well as anthropogenic), aerosol distributions and climate. We performed a set of simulations with ECHAM6-HAM2 with use of different emission inventories. Here we will present an evaluation of our simulations against available observations and reanalysis for West Africa. Further we will show the consequences of the uncertainty in emission inventories on the projected climate impacts of aerosols.

Suzuki

Process-oriented evaluation of warm cloud microphysics in climate models with a synergistic use of multi-sensor satellite observations

Kentaroh Suzuki

key words: Aerosol indirect effect, Cloud microphysics, Climate model diagnostics

There is a growing interest in the community toward novel “process-oriented” evaluations of global climate models from traditional “performance-oriented” evaluations to substantially advance our capability of climate modeling. This new trend is fueled by recent progress in satellite observations, particularly given emergence of active sensors onboard spacecraft, which enabled us to diagnose fundamental physical processes, especially when combined with passive-type measurements. Among these processes, cloud processes are one of the most uncertain components in state-of-the-art climate models and a key pathway through which aerosols influence the cloud and climate. The new “process-

oriented" model diagnostic approach should therefore be progressed to improve the cloud process representation in climate models for better predicting the aerosol indirect effect. In this presentation, I will highlight our recent studies that have exploited multi-sensor satellite observations to construct particular statistics that "fingerprint" signatures of warm cloud microphysical processes. The observation-based information is then used to evaluate microphysical processes (e.g. auto-conversion) in state-of-the-art climate models. The comparisons identified a key common bias in the process representation, i.e. too fast rain formation in models. With the aid of a process model analysis, this model bias is then attributed to fundamental uncertainty in formulation of the microphysical process parameterizations. This approach offers a novel way to constrain uncertain parameters in cloud process representations, which have been regarded as "tunable knobs" in climate models. Such a process-based model constraint on a key parameter determining the aerosol indirect forcing is also contrasted against a traditional performance-based constraint to expose a key dichotomy between them, representing a new challenge for climate modeling.

Energy budget analysis of scattering and absorbing aerosol effects on global precipitation with a global aerosol-climate model

Kentaroh Suzuki, Toshihiko Takemura

key words: Aerosol effect on climate, Absorbing aerosols, Energy budget

Equilibrium simulations conduced with a global aerosol-climate model, MIROC-SPRINTARS, are analyzed to investigate how scattering (i.e. sulfate) and absorbing (i.e. black carbon) aerosols influence the global precipitation. The model is employed to perform two types of equilibrium simulations, i.e. atmosphere-only simulations with SST fields prescribed and ocean-coupled climate simulations, both with aerosol emissions perturbed by multiplying uniform factors. The results from the two simulations are used to separate the aerosol-induced response of precipitation into "rapid adjustment" and "slow response". The model output is analyzed in the context of energy balance controls on global-mean precipitation to examine how each component of energy budget responses to perturbed aerosols over the two different time scales and to quantify relative contributions of the different components to global precipitation change. The analysis reveals a stark contrast between scattering and absorbing aerosols in their ways of changing the global precipitation. The scattering aerosols modulate the precipitation mainly through the "slow response" accompanied by changes to the global-mean surface air temperature controlled by surface energy balance. The absorbing aerosols, on the contrary, affect atmospheric energy balance to change the precipitation mainly through the "rapid adjustment" that occurs at a shorter time scale typical of atmosphere. This distinct difference between the two types of aerosols is also found to influence the proportion of sensible to latent heat fluxes. This implies that land-surface processes may respond differently to the energy balance perturbations occurring at different time scales. These results provide a useful insight into the recent issue of the black carbon effect on precipitation and may help reduce a large inter-model spread in estimates of the hydrologic sensitivity.

Takemura

Climate change and impacts due to aerosol effects in Asian region based on modeling studies

Toshihiko Takemura, Kengo Sudo, Kayo Ueda, Yuji Masutomi, Kentaroh Suzuki, Daisuke Goto

key words: aeosol, climate, model

Activities of the Climate and Clean Air Coalition (CCAC) under the United Nations Environment Programme (UNEP) focus on raising awareness and improving scientific understanding of short-lived climate pollutant (SLCP) impacts and mitigation strategies. Air pollution is especially a serious social

problem over the Asian region. Our Japanese research project is searching an optimum reduction path of SLCPs including aerosols considering not only climate change but also health and agricultural impacts. Our aerosol climate models SPRINTARS coupled with a general circulation model MIROC is used in this project. In the phase 1 experiment of the project, mass concentration and radiative forcing of major aerosols as well as health impacts by PM2.5 originating from China, East Asia, Southeast Asia, and South Asia in the present relative to the year 1980 are calculated by MIROC-SPRINTARS. In the phase 2 experiment, equilibrium experiments with some ratios relative to the present-day emission inventories for sulfur dioxide, black carbon (BC), and/or organic matter are done using the coupled-ocean MIROC-SPRINTARS in order to analyze the sensitivities of meteorological parameters (e.g., surface air temperature and precipitation) with changes in their emission amounts. The simulated results show linear trends of the surface air temperature and precipitation to the radiative forcing of sulfate aerosols, while there are not clear relationships between the change in meteorological field and the radiative forcing of BC within realistic variations of its emission amount. They depend on a change in water vapor concentration which varies with the slow response of effects of BC on the climate system.
Acknowledgements: Simulations in this study were executed with the supercomputer system of the National Institute for Environmental Studies, Japan. This study is partly supported by the Environment Research and Technology Development Fund (S-12-3) of the Ministry of the Environment, Japan and JSPS KAKENHI Grant Number 15H01728 and 15K12190.

Tan

Evaluation of modeled vertical distribution of SO2 and sulfate

Qian Tan, Mian Chin, Valentina Aquila, Gao Chen

key words: Vertical distribution, SO2, Sulfate

We evaluated the vertical profiles of both SO2 and sulfate in the AEROCOM Phase II participating models. SO2 and sulfate show significant concentration gradient in both horizontal and vertical directions. Both online and offline aerosol transport models show large difference in the vertical distribution of sulfur species from surface all the way up to lower stratosphere. Comparison with available aircraft measurements suggests models agree with observations well when SO2 concentration is high. For the volcanic plumes, the injection height and magnitude determines initial SO2 plume distribution and following transport pattern. At high altitude, where the background concentration of SO2 is often below the detection limit of the current aircraft instruments and satellite retrievals, modeled SO2 and sulfate concentration, lifetime, and budget, as well as their uncertainties can be difficult to be accurately quantified.

Tariq

Effects of Anthropogenic Methane Aerosols on Climate of Pakistan

Shahina Tariq, Sunbal Siddeque, Irfan Mahmmod

Key words:Methane aerosols,Coal,Climatic variables,Power generation

After the discovery of huge coal resources in Thar Desert of Sindh Province, Pakistan, the focus of Pakistan Government has shifted to coal power generation of 20000 MW by 2025. This target will be achieved by mining in Thar coal field and on importing coal in different parts of Pakistan. Coal

characterization has established main pollutants methane, carbon dioxide, hydrogen sulphide and sulphur that are released into the atmosphere and local water streams. Total indigenous coal production of around 3.0 million tons is being utilized in brick kilns, cement and sugar industry and hence, contributing in the production of methane aerosols. The abandoned and working coal mines give kerosene odour due to escape of methane in the atmosphere. The amount of methane released into the atmosphere is increasing with the development of the industrial sector. Methane and other pollutants are causing the greenhouse effect with the result of a gradual increase in temperatures, hence causing melting of glaciers and serious floods. The purpose of this study is to assess methane aerosols effect on climate by identifying the release of methane aerosols into the atmosphere and hence manipulating the climate by studying spatial distribution of climatic variables during the time series of 1952-2015 in Sindh Region. Results show that amount of methane in atmosphere has increased from 66.5 CMM (million cubic meters) in the year 2000 to 86.8 CMM in the year 2015. Future projections results predict that amount of methane will increase to 119 (CMM) by 2030 and will cause more floods and hence increase in Sea level. It is suggested to carry out systematic studies of the industrial pollutants in relation to the increasing requirements of power generation of the developing industrial sector to control the atmospheric pollutants and to save the country from extreme weather events.

Thomas

The Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm: Introduction, overview and status

Gareth Thomas, Matthew Christensen, Greg McGarragh, Caroline Poulsen, Adam Povey, Simon Proud, Don Grainger

key words: aerosol, satellite

The Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm is a community code for the retrieval of aerosol and/or cloud properties from visible-IR imaging satellite instruments. It is built around the optimal estimation formalism of Rodgers (2000) that offers a highly adaptable and flexible retrieval framework, which allows it to take advantage of the measurement characteristics of a wide range of sensors, including multi-view instruments and an arbitrary number of wavelength-bands. The majority of the development work has thus far been undertaken by the University of Oxford and the Rutherford Appleton Laboratory (RAL), with important contributions from Deutsche Wetterdienst (DWD).
The code has been successfully applied to a wide range of sensors including the ATSRs, MODIS, AVHRR, SEVIRI, AHI, GOES, SLSTR and VIIRS, for a range of applications from producing long-term global aerosol or cloud datasets to detection and retrieval of volcanic ash clouds. Most recently the algorithm formed “Community Code for Climate Change” (CC4CI) processor used in producing the ESA Cloud_cci datasets, and is one of three algorithms producing datasets from the Along Track Scanning Radiometers (ATSR) instruments in the ESA Aerosol_cci project. A particular emphasis on recent development is on the exploitation of a unified cloud and aerosol algorithm to produce consistent datasets for aerosol-cloud interaction studies, and on extension of these products to include broadband radiance products at top- and bottom-of-atmosphere.
This talk will give an overview of the algorithm and its capabilities, introduce the available ORAC products, and give details of how to gain access to those products, or the retrieval code itself.

Titos

A review of the effect of hygroscopic growth on the aerosol light-scattering coefficient

Gloria Titos, Paul Zieger, Betsy Andrews

key words: Hygroscopic growth, Scattering enhancement

Atmospheric aerosol particles are able to take up water and thus change their optical properties depending on the hygroscopicity and the relative humidity (RH) of the sur-rounding air. The aerosol light-scattering dependence on RH can be quantified by the scattering enhancement factor, f(RH), which is defined as the ratio between the scat-tering coefficient at enhanced RH to a reference (dry) scattering coefficient. Precise f(RH) measurements are needed for validation of model outputs and, therefore, for an accurate description of direct aerosol radiative forcing globally.
As a previous step of the f(RH) model-measurement comparison within AeroCom (see companion abstracts by Zieger et al. and Andrews et al.) we have performed a review of the different experimental designs used to measure the scattering coeffi-cient at dry and humidified conditions over the past 50 years as well as the proce-dures followed to analyze the measurements. Several empirical parameterizations for the relationship between f(RH) and RH have been proposed in the literature. These parameterizations have been reviewed and tested using experimental data representative of different hygroscopic growth behavior and a new parameterization is presented. The potential sources of error in f(RH) are discussed and their impact has been quantified using the Monte Carlo method. An overall measurement uncertainty of around 20-40% for moderately hygroscopic aerosols was estimated. The main factors contributing to this uncertainty are the uncertainty in the measured (elevated) RH, the dry reference state (degree of drying) and the nephelometer uncertainties in general. Finally, a literature survey of nephelometry-based f(RH) measurements is presented as a function of aerosol type. In general, the highest f(RH) values were measured in clean marine environments, with pollution having a major influence on f(RH). Dust aerosol tended to have the lowest reported hygroscopicity of any of the aerosol types studied. Major open questions and suggestions for future research priorities are out-lined.

Tsay

7-SEAS/BASELInE: Satellite-surface perspective of air quality and aerosol-cloud effects on the environment

Si-Chee Tsay, Adrian Loftus, Peter Pantina

key words: aerosol-cloud interaction, aerosol property, surface measurements

Southeast Asia (SEA), an extensive agrarian region, has witnessed vibrant economic growth and rapid urbanization in recent decades. Biomass burning from forest fires and slash-and-burn agricultural practices strongly modulates regional atmospheric composition. During the peak-burning season (March−April), these chemical and aerosol species degrade the regional air quality and impact the energy balance of the Earth-atmosphere system through their direct radiative effects. Downwind from smoke source regions, the transported biomass-burning aerosols overlap and overlie a persistent low-level stratocumulus cloud deck, associated with the development of the region's boreal spring cloud/rain system. Stratiform clouds cover more of the Earth's surface than any other cloud type, rendering them critical for distributing precipitable water in the Earth-atmosphere system and for modulating radiant energy and sensible/latent heat that profoundly affect weather and climate. To facilitate an improved understanding of regional air quality and aerosol-cloud effects, the 7-SEAS/BASELInE (Seven SouthEast Asian Studies/Biomass-burning Aerosols & Stratocumulus Environment: Lifecycles & Interactions Experiment) and AERONET/MPLNET deployment, along with regional contributing instruments were conducted in spring 2013−2015 over northern SEA. In this poster, we will present a baseline strategy utilized to tackle many aspects of satellite remote-sensing/retrieval and ground-based in-situ studies involving aerosols, clouds and air quality. The general backbone of BASELInE

observational network consists of AERONET's sunphotometers and SMARTLabs' radiometers, which can be deployed in a DRAGON-like (Distributed Regional Aerosol Gridded Observation Networks) configuration over a designated region to compare with airborne measurements and satellite retrievals or in a Lagrange-like setting along prevalent pathways for studying the transport and evolution of air pollutants. To critically evaluate the latter, supersites embedded in this setting include the SMARTLabs (Surface-based Mobile Atmospheric Research & Testbed Laboratories) mobile facility, MPLNET lidars, and multi-suite of chemical samplers. Thus, 7-SEAS/BASELInE, the first of its kind in the region, is an effective international collaboration.

Ullah

Spatio-Temporal Trends of Anthropogenic Black Carbon over Pakistan

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key words: black carbon, spatial distributions, Pakistan

The ever increasing anthropogenic activities like vehicle fuel combustion and high carbon concentration in the surroundings are adding a huge amount of black carbon in the atmosphere. Black Carbon is the product of incomplete combustion of fossil fuels. It increases temperature of environment and changes composition of the atmosphere, thus, showing lethal impacts on environment as well as on human health. Pakistan has been experiencing the rise in temperature, glacier melting and polluted atmosphere in recent decades. This research has been carried out to study the trends of Black Carbon in Pakistan; both spatial and temporal. A historic study based on past three decades from 1986 to 2015 has been designed to use the ground observation based data model MACCity for anthropogenic Black Carbon. Cumulative seasons are studied in this regard. The most recent seasonal trends of Carbon emission and accumulation for the year 2015 have been studied and a comparative study has been done with a satellite based dataset MERRA-2. The results indicate that the eastern parts of the country i.e., the foothills of Himalayas, the province of Punjab, and some parts of Sindh (Pakistan) have observed increasing BC accumulation during the period 1986 to 2015. The areas in the west of the country do not show significant traces of accumulation of BC. The correlation between Black Carbon and wind speed show a significant relation between them. Although there is negligible amount of anthropogenic activity in Himalayas, the areas just below Himalayan showed high accumulation rate, this is because BC saturated wind coming from south and southeast is obstructed by the mountainous range, which is responsible for its deposition in this area. The general pattern of seasonal trends show higher concentration in colder months, winter and autumn while lower concentration in spring and lowest in summer. The climatic parameters affect the transport and deposition of BC as the active monsoon winds in summer are experienced in this area, which cause the carbon to spread along the horizontal as well vertical winds and the high monsoon rainfall is also responsible for the washing away from atmosphere. The temporal trends of Black Carbon emission have showed a rapid increase rate in the selected period due to increase in anthropogenic activities in the northeast and southeast of country. This study illustrates that the changing climatic conditions in different seasons create a different scenario for transportation and accumulation of Black Carbon in Pakistan. The study will be helpful for the identification of the anthropogenic sources affecting the atmosphere and human health especially in big cities of Pakistan.

Vandenbussche

IASI dust within the ESA aerosols CCI: four different scientific approaches, their intercomparison and comparison with external data

Sophie Vandenbussche, Virginie Capelle, Lieven Clarisse, Lars Klüser, Thomas Popp

key words: dust, CCI, IASI

In the Aerosol_cci project of the Climate Change Initiative of the European Space Agency (ESA), a full-mission (~10 years) dataset of dust 10µm AOD from IASI was produced with 4 different algorithms. These algorithms are based on different retrieval techniques: look-up tables, optimal estimation, neural network and singular value decomposition. Retrieving dust aerosols from IASI has the advantage of providing AODs twice a day globally, at about 9h30 and 21h30 local solar time (thus also at night-time). In addition, using thermal infrared (TIR) wavelengths offers the opportunity of constraining complementary information: particle size, composition or vertical distribution. In this contribution, the 4 algorithms will be shortly described and comparisons will be presented over the major dust belt of the Northern hemisphere (including the Northern Atlantic Ocean, the Sahara desert, the Arabian Peninsula as well as the Central Asian desert regions). We will show intercomparisons of the 10µm AOD, which is the primary product of those 4 algorithms. In absence of existing validation dataset at 10µm, comparisons are also carried on with independent datasets observed in the visible spectrum (AERONET sun photometers, other satellite data, model data, ...). A conversion is therefore applied to obtain the 550nm AOD from the 10µm AOD retrieved using IASI measurements. The conversion method itself differs between the 4 algorithms and is highly sensitive to the dust parameters (particle size, refractive index), therefore introducing a significant additional uncertainty on AOD 550nm as compared to AOD 10µm. Based on these validation attempts, we will highlight strengths and weaknesses of the different algorithms.

Exploitation of almost 10 years of 3D dust distribution from IASI with the MAPIR algorithm for studying desert dust sources in Asia.

Sophie Vandenbussche, Nicolas Kumps, Martine De Mazière

key words: dust, source, Asia,IASI

The MAPIR algorithm, allowing to retrieve vertical profiles of the concentration of mineral aerosols from thermal infrared radiances, has been applied to the complete time series of IASI measurements (end 2007-mid 2016) along the major “dust belt” (0-40°N, 80°W-120°E). Hence, for the first time, about 10 years of 3D dust distribution are available. As a first demonstration of the applications of such a dataset, we selected the study of desert dust sources. For that kind of study, IASI has the advantage of offering measurements twice per day: one at day time (9h30 local solar time) and one during night time (21h30 LST) when the passive UV-vis instruments are blind. Vertical profiles add a new dimension to the study of dust sources: enabling us to distinguish between surface and elevated dust. In addition to the 3D dust product, we use additional products like land cover type, soil moisture, and winds. The method (that we designed) takes into account the strengths and weaknesses of the MAPIR 3D dust product. In this contribution, we explain the method developed for studying the desert dust sources and we show preliminary results of its application to Asian desert dust sources: their localization, partial diurnal cycle, and evolution over 10 years.

Wang Jingxu

Factors Affecting Aerosol Radiative Forcing

Jingxu Wang, Jintai Lin, Ruijing Ni

key words: driving factors, aerosol radiative forcing

Rapid industrial and economic growth has meant a large amount of aerosols in the atmosphere with strong radiative forcing (RF) upon the climate system. Over parts of the globe, the negative forcing of aerosols has overcompensated for the positive forcing of greenhouse gases. Aerosol RF is determined by emissions and various chemical-transport-radiative processes in the atmosphere, a multi-factor problem whose individual contributors have not been well quantified. In this study, we analyze the major factors affecting RF of secondary inorganic aerosols (SIOAs, including sulfate, nitrate and ammonium), primary organic aerosol (POA), and black carbon (BC). We analyze the RF of aerosols produced by 11 major regions across the globe, including but not limited to East Asia, Southeast Asia, South Asia, North America, and Western Europe. Factors analyzed include population size, per capita gross domestic production (GDP), emission intensity (i.e., emissions per unit GDP), chemical efficiency (i.e., mass per unit emissions) and radiative efficiency (i.e., RF per unit mass). We find that among the 11 regions, East Asia produces the largest emissions and aerosol RF, due to relatively high emission intensity and a tremendous population size. South Asia produce the second largest RF of SIOA and BC and the highest RF of POA, in part due to its highest chemical efficiency among all regions. Although Southeast Asia also has large emissions, its aerosol RF is alleviated by its lowest chemical efficiency. The chemical efficiency and radiative efficiency of BC produced by the Middle East–North Africa are the highest across the regions, whereas its RF is lowered by a small per capita GDP. Both North America and Western Europe have low emission intensity, compensating for the effects on RF of large population sizes and per capita GDP. There has been a momentum to transfer industries to Southeast Asia and South Asia, and such transition is expected to continue in the coming years. The resulting relocation of emissions would mean drastic changes in both the spatial distribution and the magnitude of RF, with consequences on regional and global climate forcing. Our findings are relevant to global aerosol control and climate mitigation.

Wang Minghuai

Emergent constraints for aerosol indirect effects

Minghuai Wang, Shipeng Zhang, Cheng Gong

key words: aerosol indirect forcing, emergent constraints

It has been a challenge to constrain aerosol indirect effects through direct constraints on simulated aerosol and cloud fields in current climate. Our previous work proposed a new metric called rain frequency susceptibility to provide an emergent constraint for cloud lifetime effects of aerosols. In this study, we compare rain frequency susceptibility with several other metrics proposed in literatures for constraining cloud lifetime effects of aerosols. Our results showed that rain frequency susceptibility provide a better constraint than some other proposed metrics. We further showed that the magnitude of rain frequency susceptibility from satellite observations depends on whether cloud droplet number concentrations or aerosol index are used in its definition. Our results show that constraining model results using rain frequency susceptibility from both definitions provide further insights on model discrepancies with observations.

Wang Qiuyan

Impact of anthropogenic aerosols from global, East Asian, and non-East Asian sources on East Asian summer monsoon system

Qiuyan Wang, Zhili Wang, Hua Zhang

key words: EASM, Anthropogenic aerosols, East Asian emissions, non-East Asian emissions

The impact of the total effects due to anthropogenic aerosols from global, East Asian, and non-East Asian sources on East Asian summer monsoon (EASM) system is studied using an aerosol-climate online model BCC_AGCM2.0.1_CUACE/Aero. The results show that the summer mean net all-sky shortwave fluxes averaged over East Asian monsoon region (EAMR) at the top of the atmosphere (TOA) and surface reduce by 4.8 and 5.0 W m-2, respectively, due to the increases of global aerosol emissions in 2000 relative to 1850. Changes in radiations and their resulting changes in heat and water transport and cloud fraction contribute together to the surface cooling over EAMR in summer. The increases in global anthropogenic aerosols lead to a decrease of 2.1 K in summer mean surface temperature and an increase of 0.4 hPa in summer mean surface pressure averaged over EAMR, respectively. It is shown that the changes in surface temperature and pressure are significantly larger over land than ocean, thus decreasing the contrast of land-sea surface temperature and pressure. This results in the marked anomalies of north and northeast winds over eastern and southern China and the surrounding oceans in summer, thereby weakening the EASM. The summer mean precipitation averaged over the EAMR reduces by 13%. The changes in non-East Asian aerosol emissions play a more important role in inducing the changes of local temperature and pressure, and thus significantly exacerbate the weakness of the EASM circulation due to local aerosol changes. The weakening of circulation due to both is comparable, and even the effect of non-local aerosols is larger in individual regions. The changes of local and non-local aerosols contribute comparably to the reductions in precipitation over oceans, whereas cause opposite changes over eastern China. Our results highlight the importance of aerosol changes outside East Asia in the impact of the changes of anthropogenic aerosols on EASM.

Wiriya

Estimation of emission of PM2.5- and PM10-bound polycyclic aromatic hydrocarbons from biomass burning in the upper northern part of Thailand during the haze episode (2010-2015)

Wan Wiriya, Somporn Chantara, Praphatsorn Punsompong

key words: biomass burning, emission rate, air pollution, PAHs, PM

Northern of Thailand are suffering from air pollution in dry season almost every year. The main source of air pollution is biomass burning (forest fire and open burning from agricultural area). This study aimed to estimate emission of PM2.5- and PM10-bound polycyclic aromatic hydrocarbons (PAHs). The emission factor (EF) of air pollutants form biomass burning (forests and agricultural residues including rice straw and maize residue) were calculated from previous studies of environmental chemistry research laboratory, faculty of Science, Chiang Mai University. The emission rates (ERs) was estimated by EF of biomass burning and burnt area from MODIS Landsat 5TM PM. The result found that ERs of forest area was significant higher than agricultural area in every year. The ERs of PM2.5- and PM10-bound PAHs recorded in 2010-2015 form open burning in descending order were forest dipterocarp > mixed deciduous > maize residue > rice straw. Furthermore, ERs of total PAHs was highest on March in 2010. The ERs of toxicity was highest in Mea Hong Son province, western part of upper northern Thailand due to open burning area. It was observed that the emission of toxic PAHs from leaf litter burning was higher than from agricultural residue burning. The result from this study will be useful for modeling application and regulatory action of air quality management in the region.

Wu

The transport of sea-spray spume during high-wind conditions and its effects on sea salt aerosol emissions

Lin Wu, Qing-cun Zeng, Xue-Ling Cheng

key words: sea-spray spume, high-wind conditions, vertical flux, sea salt aerosol

Ocean-produced sea-salt aerosols are the most numerous naturally emitted aerosols, and remain one of the most poorly constrained aerosols in the global atmosphere, both in terms of their emissions and atmospheric burdens. The starting point to model the emission of sea-salt aerosols is to model the sea-spray generation function. However, for the large size spume droplets, especially during high-wind conditions, the production physics is less explored and the understanding of the spume vertical flux is limited. Based on the observational data and characteristic analysis of high-wind atmospheric boundary layer (ABL) above the South China Sea, the vertical transport of spumes is studied and simulated. It is revealed that the gusty wind with coherent structure exist during high winds (both the typhoon and the cold-surge conditions), and is favorable for the vertical transport of the large size droplets. Using the Lagrangian stochastic model, the trajectories of spume droplets with different size under different wind speeds in the range 12–35 m s-1 are calculated, and the uplifting ratio of spume that can reach ABL 100 m height is parameterized. Then the vertical flux of large size spume and the mass concentration are evaluated. This numerical result shows that the spume with large particle size can entrain into the ABL during high winds and contribute to the sea salt aerosol emissions.

Xie

Image fusion of MODIS AOD products based on the maximum likelihood estimate method

Yanqing Xie, Yong Xue, Jie Guang

key words: AOD, image fusion, maximum likelihood method, validation

Comparing with traditional ground station measurements, remote sensing provides a possibility for the spatial continuity monitoring of aerosol optical depth (AOD). Based on these advantages, satellite measurements are widely applied to the monitoring of aerosol in recent decades. However, the values of the AOD provided by different satellites are not consistent due to the differences between characteristics of sensors and aerosol retrieval algorithms. Through fusion of image from different remote sensors and methods, we can improve the image spatial coverage of valid values and accuracy, and further improve its application range. In this paper, we use the maximum likelihood method to determine the weights of various images involved in fusion and produce an AOD data set of Brazil in 2008 based on two AOD products: DeepBlue and DarkTarget that obtained from the Moderate Resolution Imaging Spectroradiometer (MODIS). First of all, we compare the values of various products with the ground observation values obtained from the Aerosol Robotic Network (AERONET) to determine the error size of the pixels. Then, we analyse the relationship of the error size, the value of the remote sensing observations and the value of surface albedo, so as to determine the uncertainties. Finally, we determine the weight of the fusion according to uncertainties of the different products. After comparing the original data and the fused data with ground observation values, we find that the absolute error of the fused image is smaller than any of the original data and the root mean square error of fused images is no more than any of original data. Meanwhile, the proportion of the fused AOD

image with valid value is larger than any of the original products. Thus, the fusion improves the accuracy of the data and increases the spatial coverage.

Xin

The observation-based relationships between PM2.5 and AOD over China

Jinyuan Xin

key words: PM2.5, AOD

China is the main source of natural and anthropogenic aerosol in Asia. This is the first investigation of the generalized linear regressions of PM2.5 and AOD with the CARE-China network over the large high-concentration aerosol region during the period from 2012 to 2013. The map of the PM2.5 and AOD levels showed large spatial differences in the aerosol concentrations and aerosol optical properties over China. The ranges of the annual mean PM2.5 and AOD were 10～117 μg/m3 and 0.12～1.11 from the clean regions to seriously polluted regions, from the almost 'arctic' and the Tibetan Plateau to tropical environments. Fine particle pollution is very serious in China, with high PM2.5 and AOD throughout China except for the Tibetan Plateau, South Sea and the primeval forests. In the minority areas, the annual-mean PM2.5 concentration from 10 to 27 μg/m3 was close to the level of Europe and America . But in the industrialized domains of China (eastern, northeastern, southeastern China), the annual-mean PM2.5 concentration was from 40 to 100 μg/m3, which was approximately four to ten times higher than in the United States and in Europe. It is important to monitor the spatial and temporal distribution of the PM concentration using ground stations, satellites and models in the present and future. This work found a linear correlation between PM2.5 and AOD in the various ecosystems of China. However, the linear regression functions exhibited large differences in various regions and seasons due to variations in the aerosol components and weather conditions, which differed from those of the Europe and US. The linear regression functions (PM2.5 = A*AOD + B) exhibited large differences in different regions and seasons. The slopes (A) were from 13 to 90, the intercepts (B) were from 0.8 to 33.3, and the correlation coefficients (R2) ranged from 0.06 to 0.75. The slopes (A) were much higher in the north (41～99) than in the south (13～64) because the extinction efficiency of hygroscopic aerosol was rapidly increasing with the increasing humidity from the dry north to the humid south. Meanwhile, the intercepts (B) were generally lower, and the correlation coefficients (R2) were much higher in the dry north than in the humid south. However, the seasonal linear regression functions and correlation coefficients exhibited large or small differences within regions, which indicated that the weather conditions and the aerosol components affected the relationships between PM2.5 and AOD. We found there was high consistency of AOD vs PM2.5 for all sites in three ranges of the atmospheric column precipitable water vapor (PWV). The segmented linear regression functions were y=84.66x+9.85 (PWV<1.0), y =69.47x+11.87 (1.0<PWV<2.5), and y=52.37x+8.59 (PWV>2.5). The correlation coefficients (R2) were high from 0.64 to 0.70 across China. The segmented linear regression functions applied across China with high correlation coefficients. The relationships of PM2.5 and AOD can be used to verify and revise the aerosol models and satellite remote sensing for China.

Yang Fanglin

Radiative Forcing and Climatic Impact of the Mount Pinatubo Volcanic Eruption

Fanglin Yang

key words: Volcanic Aerosols, Radiaitve Forcing, Temperature Change

The volcanic eruption of Mount Pinatubo in the Philippines, which occurred on 15 June 1991, injected the largest amount of gaseous sulfur dioxide (SO2) into the stratosphere in the 19th century. Aerosol particles, converted from the gaseous SO2, spread all over the globe and were suspended in the stratosphere for a few years. They imposed a large impact on the atmospheric radiation, temperature, circulation and chemical constituents. This study is focused on the radiative forcing of the Pinatubo volcanic aerosol and the atmospheric responses to this forcing. Changes in radiative fluxes and atmospheric heating rates induced by the Pinatubo aerosol were computed for the two years following the eruption. The absorption of terrestrial and solar near–infrared radiation by the Pinatubo aerosol radiatively heated the middle and lower stratosphere. The back–scattering of solar UV and visible radiation by the Pinatubo aerosol radiatively cooled the troposphere. Cloudiness exhibited a large influence on the calculated radiative forcing. Both statistical tools and atmospheric general circulation model were used to detect and separate the signals of the Pinatubo aerosol forcing and ENSO events in the observed surface air–temperature anomalies over land. It was found that the 1991~1992 El Niño event contributed about –0.6°C to the observed cooling of about –1.0°C over North America in JJA 1992. The average temperature change over Eurasia, North America, South America and Africa reached about –0.5°C in JJA and SON 1992 and SON 1993 with the ENSO signals removed. The signal of SST anomalies is stronger in the troposphere and near the surface than in the stratosphere, while the signal of the Pinatubo aerosol forcing is strongest in the lower stratosphere.

Yang Yuanjian

Impacts of aerosols on cloud parameters and precipitation intensity over East Asia monsoon zone

Yuanjian Yang, Yunfei Fu, Biwen Wu

key words: Aerosol, Cloud parameters, Precipitation, East Asia summer monsoon zone

This study investigate the East Asian summer monsoon area (18°-45°N, 100°-135°E) by dividing it into 7 sub-regions: East China (EC), South China (SC), East China Sea(ECS), Sichuan Pen Di (SPD), North China (NC), Diao Yu Dao (DYD), Yellow sea and its surrounding area (YC). By using TRMM satellite data during 1998-2013 and MODIS Aerosol Optical Depth (AOD) and cloud data during 2000-2013, NCEP reanalysis data and soundings data, aerosol-cloud-precipitation interaction are diagnosed and studied. For the relation between aerosols and cloud micro-parameters, the correlation between them showed large difference among various phases/areas.For the relation between precipitation cloud parameters and surface rain rate (RR), seen from the average of precipitation cloud with various phases, along with the increase of cloud effective radius(CER), RR increased over land, while decreased over ocean, which is possibly due to the lack of cloud nuclei over ocean so that the rain drop is prevent from growing; For the relation between aerosol and RR, the correlation of AOD and RR which is concluded from AOD-CER-RR interaction indirectly is consistent with the direct statistics: along with the increase of AOD, RR had an increasing (decreasing) trend over EC, SPD and DYD (SC and YS), while over ECS RR had a relatively smaller increasing trend. Therefore, the impact of aerosols on RR has its local characteristics.

Yu

Study of particle formation and growth with an advanced particle microphysics model and implications to aerosol indirect radiative forcing

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key words: Nucleation, particle formation and growth, cloud condensation nuclei (CCN), global aerosol modeling, aerosol indirect radiative forcing.

Through acting as cloud condensation nuclei (CCN), atmospheric particles modify cloud properties and precipitation and thus indirectly impact the hydrological cycle and climate. New particle formation (NPF) is an important source of CCN. The large diversity in the global distribution of CCN abundance predicted by different models contributes to the large uncertainty in aerosol indirect radiative forcing (IRF), highlighting the necessity to improve the representation of particle formation and growth processes in the global models. We have developed a computationally efficient size-resolved advanced particle microphysics (APM) model and incorporated it into GEOS-Chem and CESM-CAM5. GEOS-Chem/APM and CESM-CAM5/APM contain a number of advanced features for global aerosol simulations, including up-to-date NPF schemes, size-resolved sectional particle microphysics, online comprehensive SOx-NOx-Ox-VOCs chemistry, consideration of all major aerosol components, distinction of particles of different types (secondary particles, primary organic carbon, black carbon, dust and sea salt particles) with amount of secondary species coated on primary particles resolved, and online aerosol-cloud-radiation calculation. Here we employ GEOS-Chem/APM and CESM-CAM5/APM to study the contributions of NPF to global CCN based on different nucleation schemes. The nucleated particles are added into the first bin (wet size ~ 1.5 nm) of the secondary particles, and the processes to grow them to large sizes include kinetic condensation of H_2SO_4 and low volatile secondary organic gases (SOG), equilibrium uptake of nitric acid gas and ammonia, partitioning uptake of semi-volatile SOG, and self-coagulation. The impact of cloud processing and aqueous chemistry on particle size distributions is explicitly simulated. We show that global distributions of CCN abundance for pre-industry and present emissions and aerosol IRF based on different nucleation schemes differ significantly. Comparisons of simulated particle size distributions and particle number concentrations based on different schemes with observations will be presented and suggestions to reduce aerosol IRF uncertainty will be discussed.

Zhai

Sensitive analysis of one haze episode in Nov. 2012 over Beijing by GRAPES-CUACE aerosol adjoint model

Shixian Zhai, Xingqin An, Tianliang Zhao

key words: GRAPES-CUACE aerosol adjoint model, Adjoint sensitivity analysis, Emission sources tracking

The GRAPES-CUACE (Global-Regional Assimilation and Prediction System coupled with CMA Unified Atmospheric Chemistry Environment) aerosol adjoint model was applied in tracking more sensitive emission sources of one haze episode in Nov. 2012 over Beijing. Through synoptic analysis, under the weak pressure between two high pressures from Nov. 19th to Nov. 20th and with growing relative humidity, near ground Beijing was mainly under the influence of southerly wind at daytime and easterly wind at night. Then during the daytime of Nov. 21st, easterly wind field that carried abundant water vapor dominated over Beijing. Accordingly, pollutants converged ahead of the Tai-hang Mountains, and the increase of water vapor promoted hygroscopic growth of local particles. The observed and simulated results showed that two successive PM2.5 concentration peaks (at 05:00 and 23:00 on Nov. 21st 2012) appeared during this haze episode, and the two successive PM2.5 concentration peaks were set as the objective functions. The adjoint sensitivity results revealed that: ①In this episode, the PM2.5 concentration peak in Beijing had a quick response to local emission sources in about 1-2 hours,

while it took about 7-8 hours for surrounding emission sources. For the first PM2.5concentration peak, surrounding emissions accounted for 65.4% of its primary emissions, while it was 34.6% for local emissions; for the second peak, surrounding and local emissions contributed 59.0% and 41.0% respectively. ②There were obvious discrepancies among different primary emission constituents with sulfate accounted for the most (39%-45%), followed by suspended dust (39%-40%), organic carbon (10%-14%) and black carbon (5%-8%). All in all, this research showed the high efficiency of the GRAPES-CUACE aerosol adjoint model in tracking key emission sources of different constituents during pollution episodes and in assisting the design of air pollution control schemes.

Zhang Hua

The Simulation Study of Global Distribution of Temporal and Spatial Variation of PM2.5 Concentration

Hua Zhang, Dongdong Yang, Shuyun Zhao

key words: PM2.5, anthropogenic aerosol, natural aerosol

The global distribution of temporal and spatial variation of column concentration of PM2.5 as well as anthropogenic and natural aerosols contributed to the PM2.5 from the year of 1850 to 1980 and 1980 to 2010 was simulated in this work by using an aerosol-climate online coupled model of BCC_AGCM2.0.1_CUACE/Aero. Then, we analyzed the different contributions of anthropogenic and natural aerosols to the PM2.5. The results show that the column concentration of PM2.5 increases significantly over the globe in the period of 1850 to 1980, especially in the Arabian Peninsula, the north of China and the Sahara Desert in the Northern Hemisphere. The increasing of the column concentration of anthropogenic aerosols in the PM2.5 is mainly due to sulfate aerosols, especially in North American, Europe and the eastern of China. As to the seasonal changes of PM2.5 concentration, the variation of anthropogenic aerosols contributes the largest of 87% in autumn, the minimum of 31% in spring and almost equal percentage to natural aerosols both in winter and summer. In the period of 1980 to 2010, the global change of column concentration of PM2.5 differs greatly, it increases respectively in the south and east of Asia, the west and south of the Sahara Desert while decreases sharply in the Europe, central Asia and the northern center of Africa. Column concentration of anthropogenic aerosols in the PM2.5 is decreased in North American and Europe while increased in East and Southeast Asia and changes largely in summer too. Whereas, the corresponding natural aerosols is reduced sharply in desert regions, and these changes in winter and spring are both significant. As to the seasonal changes of PM2.5, the contribution percentage of change of anthropogenic aerosols to the total change of PM2.5 is reducing, all less than 50%.

Zhang Meigen

Model analysis of soil dust impacts on boundary layer meteorology and air quality over East Asia in April 2015

Meigen Zhang, Lei Chen

key words: dust aerosol, WRF-Chem

An online coupled meteorology–chemistry–aerosol model (WRF–Chem) is used to quantify the impacts of soil dust on radiative forcing, boundary layer meteorology and air quality over East Asia. The simulation is conducted for 14–17 April 2015, when an intense dust storm originated from the Gobi

desert and transported to North China. An integrated comparison analysis using surface observations, satellite and lidar shows excellent performance of WRF–Chem model on meteorological parameters, pollutant concentrations, aerosol optical characteristics, and also the spatiotemporal evolution of the dust storm. The maximum aerosol optical depth induced by dust aerosols is simulated to be exceeding 3.0 over dust source areas and 1.5 over the downwind regions. Dust has a cooling effect (−1.19 W m-2) at the surface, a warming effect (+0.90 W m-2) in the atmosphere, and a relative small forcing (−0.29 W m-2) at the top of atmosphere averaged over East Asia from 14–17 April. Due to the impacts of dust aerosols, the near–surface air temperature is decreased by 0.04 °C in the daytime but increased by 0.14 °C at night. The relative humidity exhibits an increase of 0.1% in the daytime and a decrease of 0.3% at night. The maximum decrease in wind speed of ~ 0.1 m s-1 is found over the North China Plain (NCP). The planetary boundary layer height during the daytime exhibits a maximum decrease of 16.34 m and 41.70 m over dust sources and NCP, respectively. Consideration of the impacts of dust–related heterogeneous chemistry reactions, pollutant concentrations are significantly influenced, with a maximum decrease of up to 1.66 ppbV for SO2, 7.15 ppbV for NOy, and 35.04 μg m-3 for NO_3^-, and a maximum increase of up to 9.47 μg m-3 for SO_4^(2-)over the downwind areas.

Zhang Minghua

Regime Dependence of Aerosol-Cloud Interactions

Jingyi Chen, Minghua Zhang, Yangang Liu, Yiran Pen

key words: aerosol indirect effect, cloud particle size distribution

The number concentration and size distribution of cloud particles are two key factors determining the radiative effects of clouds. Aerosols affect both these factors to produce the indirect radiative effect that is considered to cause climate cooling. In most current climate models, these factors are parameterized based on one or two-moment cloud microphysical schemes in which the number of cloud particles increases with the number of aerosol particles. The simple parameterizations tend to overestimate the aerosol indirect effects in climate models. This study uses the accurate representations of cloud droplet spectrum and its relationship with aerosol distribution as well as large-scale atmospheric forcing to the understanding and quantification of aerosol-cloud interactions. It demonstrates and classifies different regimes of aerosol distribution and atmospheric vertical velocity in which distinct nonlinear dependence of cloud droplet numbers and size distributions on aerosols and vertical velocity are found.

Zhang Qi

The variation and trends of MODIS C5 & C6 products errors in the recent decade over the background and urban areas of North China

Qi Zhang, Jinyuan Xin, Yan Yin, Lili Wang, Yuesi Wang

key words: Aerosol Optical Depth (AOD), MODIS C6, MODIS C5, error

Using ten-year (2004-2013) ground-based data of the Beijing Forest and Beijing City in the North China, we evaluated the high-quality MODerate resolution Imaging Spectroradiometer (MODIS) Aerosol Optical Depth (AOD) C5 and C6 products precision and discussed the sensor degradation issues. The annual mean AOD and Angstrom exponent (α) were 0.20±0.02 and 0.83±0.15 in the background over ten years, and they were 0.59±0.07 and 1.13±0.08 in the urban, respectively. Ground-based AOD had both slightly declined trends, with variations of 0.023 and 0.057 over the past ten years in the

background and urban, respectively. There were large differences in the eight kinds of MODIS AOD products (Terra vs. Aqua, C5 vs. C6, DT vs. DB, and DTDB) in the background and urban areas, but the products had similar seasonal variations and similar annual trends of the retrieval errors. In the background, more than 62% of DT matchups for C5 and C6 products were within the NASA's expected error (EE). In the urban, 69%~72% of C6 DB retrievals were falling within EE. The new dataset C6 DTDB had better performance in the background, whereas it overestimated by 37%~41% in the urban caused by error in surface reflectivity estimation. The range of monthly absolute error ((MODIS-Observed)AOD) was large from -0.21 to 0.28 in the background and from -0.63 to 0.48 in the urban. From the background to the urban areas, the annual errors of Terra and Aqua had slightly increased by 0.0023~0.0158 and 0.0011~0.0124 per year, respectively, which implied that the two MODIS sensors had degraded slowly.

Zhang Shipeng

Structure Uncertainties in Aerosol-Cloud-Interactions in CAM5

Shipeng Zhang, Minghuai Wang, Po-lun Ma

key words: aerosol-cloud interactions, structure uncertainty, CAM5

Aerosol-Cloud-Interactions (ACI) are one of the most uncertain parts of estimating climate radiative forcing in current global climate models. In this study, we investigate ACI uncertainties in CAM5 models with several different physical parameterizations (so-called structure uncertainty). Four versions of CAM5 are performed to investigate the uncertainty of ACI by configuring the models with prescribed large-scale circulation features, which is so-called "off-line" mode. These four versions consist of CAM5.3 with default schemes (CAM5.3), CAM5.3 with Cloud Layers Unified By Binormals (CAM5.3-CLUBB), CAM5.3 with updated microphysical scheme (CAM5.3-MG2), and the combination of them (CAM5.3-CLUBB-MG2). Some key regions with the most evident spread of ACI in models are found, such as North Pacific Ocean where storm tracks prevail and Southeast Pacific Oceans where low clouds dominates. By examining aerosol, precipitation, cloud and radiation processes in these regions, some process-level analysis are performed to find out the essential reasons cause the large uncertainty of ACI in different versions of CAM5.3. Single column models of CAM5 are used to reproduce global run results and to further investigate uncertainties in ACI in regions where structure uncertainties are large.

Zhang Xiao-Xiao

Modeling of dust deposition in central Asia

Xiao-Xiao Zhang, Xi Chen, Brenton Sharratt

key words: central Asia, Dust deposition, Desert,Numerical model

The deposition of dust particles has a significant influence on the global bio-geochemical cycle. Currently, the lack of spatiotemporal data creates great uncertainty in estimating the global dust budget. To improve our understanding of the fate, transport and cycling of airborne dust, there is a need for long-term records of dust deposition and quantified validation. Located in the east part of central Asia, Xinjiang Province of northwestern China has long been an essential geographical bridge which connects the European and Asian continents. We used the WRF-Chem model to simulate dust deposition during the 21st century based on the environmental monitoring records of major cities in

Xinjiang. We further analyzed the results to identify factors and uncertainties that influence dust deposition. Our results suggest that high dust deposition occurred in the central Asia arid region. The model performed well and captured spatial and temporal variations in dust deposition. The highest dust deposition was observed in Hotan, located in the southern Taklamakan Desert, with a range of 1000-1600 t•km-2•a-1, which was in good agreement with modeling results. This work will strengthen our comprehension on aerosol transport and deposition modeling in the central Asian desertification region.
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Zhou

The effective radiative forcing due to partly internally mixed and externally mixed anthropogenic aerosols and their effects on global climate

Chen Zhou, Hua Zhang, Shuyun Zhao, Jiangnan Li

key words: anthropogenic aerosols, climate effects, effective radiative forcing, internal mixing, external mixing

The total effective radiative forcing (ERF) of partly internally mixed (PIM) anthropogenic aerosols by considering the aerosol-cloud interaction (ERFaci) since the pre-industrial times and their effects on global climate have been estimated by using an aerosol-climate online coupled model of BCC_AGCM2.0 and compared with externally mixed (EM) aerosols in this work. The total global mean ERF since the pre-industrial times was thus obtained to be -1.02 W m-2 including -0.85 W m-2 of ERFaci and -0.17 W m-2 of ERFari for PIM case, and -1.68 W m-2 including -1.38W m-2 of ERFaci and -0.30W m-2 of ERFari for EM case, respectively. The global mean surface temperature, water evaporation and precipitation have been accordingly reduced for 0.99 K, 0.08 mm day-1, 0.09 mm day-1 in PIM case, and 1.84K, 0.14 mm day-1, 0.15 mm day-1 in EM case, respectively. However, the relative humidity near the surface was slightly increased in both cases. The Hadley circulation was suppressed due to the cooling effect of anthropogenic aerosols, and the intertropical convergence zone has been southwardly moved in both cases and thus the equatorial precipitation zone. In conclusion, the internal mixing could greatly reduce the negative ERF and cooling effect of anthropogenic aerosol.

Zieger

Evaluation and improvement of the parameterization of aerosol hygroscopicity in global climate models using in-situ surface measurements

Paul Zieger, Gloria Titos, Betsy Andrews

key words: Aerosol light scattering, Aerosol hygroscopicity

Ambient aerosol particles can take up water and thus change their optical properties depending on the hygroscopicity and the relative humidity (RH) of the surrounding air. Knowledge of the hygroscopicity effect is of importance for radiative forcing cal-culations but is also needed for the comparison or validation of remote sensing or model results with in situ measurements. Specifically, the particle light scattering depends on RH and can be described by the scattering enhancement factor f(RH), which is defined as the particle light scattering coefficient at defined RH divided by its dry value. Here, we will present insights from surface-based measurements of f(RH) across Europe and will show its importance for model validation (Zieger et al., 2013). In ad-dition, we will demonstrate on why the

coarse mode is important when modeling or predicting f(RH) from auxiliary aerosol in-situ measurements. For this, we will show the implications by presenting the results of a recently performed columnar optical closure study (Zieger et al., 2015) where ground-based and airborne in-situ measurements were compared to AERONET measurements and retrievals. Finally, we have recently started to harmonize all globally available surface based f(RH)-measurements to provide a benchmark data set for model evaluation and improvement of hygroscopicity parameterizations within global climate models. We will show first results on the data harmonization and discuss its difficulties. As an outlook we will present the outline of the planned model-measurement comparison within AeroCom.

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