ABSTRACTS

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and the

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in alphabetical order by presenter

ORAL title
POSTER title

Allen, Robert

Elevated Aerosol Pollution in a Warmer World: The Role of the Land/Sea Warming Contrast and Enhanced Continental Aridity

Most climate models simulate an increase in anthropogenic aerosol species in response to warming, particularly over the Northern Hemisphere (NH) mid-latitudes during June-July-August (JJA). Although the causes are uncertain, a recent analysis argues the increase in anthropogenic aerosol is related to a decrease in wet removal, primarily due to reduced large-scale precipitation. Here, we expand upon this notion and show that the increase in aerosol burden and hydrological changes are related to a robust climate change phenomenon — the land/sea warming contrast. Enhanced land warming is associated with reductions in lower-tropospheric humidity, low clouds and soil moisture over land, as well as less large-scale precipitation and aerosol wet removal, particularly in the NH mid-latitudes during JJA. Idealized simulations with a state-of-the-art climate model show that muting the land-sea warming contrast weakens these hydrological changes, and in turn, stifles the aerosol increase. Moreover, idealized simulations that only feature land warming yield enhanced continental aridity and an increase in aerosol burden. Thus, unless anthropogenic emission reductions occur, our results add confidence that a warmer world will be associated with enhanced aerosol pollution.

An, Qi

Simulation Study of Nitrate AOD and Effective Radiative Forcing

Many researches on sulfate aerosols had been done during the last two decades, which had contributed significantly to our understanding of the emission, concentration, optical properties and radiative forcing of sulfate in the atmosphere; whereas these kinds of study on nitrate was not given much attention before, since the concentration of nitrate aerosol in the atmosphere was much less than sulfate aerosol. Recent studies show that the scattering properties of nitrate are stronger than that of sulfate in some wave bands. Besides, the proportion of nitrate in total anthropogenic aerosols shows an increasing trend since the emissions of sulfate aerosol will be greatly reduced due to the controlling to its precursors at present and in the future, while the emissions of nitrate aerosol increase rapidly, and these changes will lead to higher radiative forcing caused by nitrate than that of sulfate. It is very likely that nitrate will become an important radiative forcing factor to affect climate change at regional and seasonal scales in the future. Therefore, in order to get some new insights into the concentration and radiative forcing of nitrate, this research have analyzed the distribution of emissions and simulated the concentration, AOD and radiative forcing of nitrate with the aerosol-climate coupled model BCC_AGCM_CUACE2.0 developed by the National Climate Center of the China Meteorological Administration (NCC/CMA). The main conclusions are as follows: (1) on a global scale, the loading of nitrate has increased by 1.43 mg/m2 from 1850 to 2010. And the increased nitrate loading was mainly distributed in East Asia, South Asia, Europe, and North America, especially in East Asia (the maximum is about 19.24 mg/m2). In 2100, the loading of nitrate would increase by 0.45~1.04 mg/m2 relative to 1850, and the increased nitrate loading would be mainly distributed in EA and EU. And the loading of nitrate increased obviously in winter. (2) Since 1850, the Radiative Forcing from aerosol–radiation interactions (RFari) of nitrate is –0.14 W/m2 in 2010, and the high value regions are in East Asia, South Asia, Europe, and North America. When it comes to 2100, the RFari would be –0.044~ –0.099 W/m2 relative to 1850. The highest value of RFari appeared in summer or winter, this is the result of influence of solar zenith angle, relative humidity, cloud cover and surface albedo. (3) Since 1850, the Effective Radiative Forcing from aerosol–radiation interactions (ERFari) of nitrate is about −0.26W/m2 by 2010, and it's a little bigger than the RFari. In 2100, the ERFari of nitrate would be about −0.054~ −0.15W/m2 relative to 1850.

Andrews, Betsy

What is dry? The effect of aerosol water on particle light scattering at low relative humidity

Atmospheric aerosol particles contribute to radiative forcing by impacting how incoming solar radiation is scattered and absorbed. This influence is determined by the amount, size, shape and composition of the particles. The latter three factors are, in turn, affected by whether there is water associated with the particles. Thus, to truly understand how particles contribute to Earth's radiation budget, the influence of water on the aerosol optical properties needs to be assessed. This presentation will explore the question of 'What is a valid definition of dry RH?' in terms of aerosol light scattering coefficient. There are different meanings of 'dry' for different communities. For example, WMO/GAW has recommended that measurements of aerosol properties be made at low relative humidity (RH<40%; WMO, 2016) under the assumption that, for those conditions, associated aerosol water would have a minimal contribution, and thus aerosol optical properties would be comparable across measurement sites. Further, RH<40% was considered a 'do-able' value both in terms of cost and relative ease to achieve. In contrast, 'dry' for model simulations implies that the RH=0%. Here we look at changes in optical properties at low RH conditions using both in-situ measurements and model simulations. We investigate the changes in observed in-situ aerosol scattering coefficient as a function of RH from ~50 surface sites. We look for patterns in the RH/aerosol scattering relationship as a function of other aerosol properties that are proxies for aerosol size and composition. These observational results are compared with data from two AeroCom models (GEOS5-MERRAero and CAM5.3-Oslo). These models provided simulations of aerosol optical properties at several relative humidity values including RH=0% and RH=40% for the Phase III AeroCom project "In-situ Measurement Comparison (Optical Properties)" (https://wiki.met.no/_media/aerocom/INSITU_AeroComPIII_description.pdf). This investigation has implications for model/measurement comparisons where discrepancies in the amount of water associated with aerosol particles may lead to larger uncertainties. It is also an important aspect for interpreting the scattering enhancement factor which is the ratio of aerosol scattering coefficient at a high RH to scattering at a designated 'dry' RH. Historically, the enhancement factor has often been determined by assuming scattering below 40% RH is representative of dry aerosol. This work will play a key role in our future efforts to evaluate global model simulations of the aerosol scattering enhancement (see Burgos et al. presentation).

Aoki, Kazuma

Long-term measurements of aerosol optical properties in Japan

Aerosols and cloud play an important role in the radiative balance of the atmosphere. We provide the information, in this presentation, on the aerosol optical properties with respect to their temporal and spatial variability in several Japan sites. We started the long-term monitoring of aerosol optical properties by using sky radiometer (POM-01: PREDE Co. Ltd., Tokyo, Japan) at Sapporo (43.1N, 141.3E) since 1997, at Toyama (36.7N, 137.2E) since 2002, and ground-based sites and ship-borne site. 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 volume size distribution clearly showed seasonal and temporal variability, with a vernal maximum (e.g. Anthropogenic and Asian dust) and an autumnal to winter minimum in Japan. Sometimes we observed forest fire events from Siberia. In this study, we present the temporal and spatial variability of long-term measurements of Aerosol optical properties in Japan sites, applied to validation plan of satellite and numerical models. This project is validation satellite of GCOM-C/SGLI, JAXA and other. We will show results of validation of satellite.

Aquila, Valentina

Changes in upper troposphere/lower stratosphere aerosol since 1980 in the Goddard Earth Observing System (GEOS) model

Most aerosols enter the UTLS through tropical upwelling. In the last 6 years, however, new analyses of satellite observations have identified a region of enhanced aerosol extinction in the UTLS above Asia during the summertime. This enhancement, called the Asian Tropopause Aerosol Layer (ATAL), is connected to the Asian monsoon convective system, which transports pollutants and aerosols across the tropopause from the troposphere. While the specific composition of the ATAL is not well quantified, the few in-situ measurements available suggest that carbonaceous aerosol contribute significantly to the ATAL. Its sources and the anthropogenic contribution are also not well known. The ATAL is visible in observations since the late 1990s: the appearing of the ATAL in the late 1990s could be related to the sudden increase in Asian emissions (if they are indeed a major contributor to ATAL), or it might have simply been masked by the aerosol from the Mt. Pinatubo eruption in the years prior.
In this talk we will show changes in extinction and composition of UTLS aerosol in high resolution simulations performed with the NASA Goddard Earth System Model (GEOS-5) from 1980 to 2016. In particular, we will analyze the MERRA-GMI replay simulation, a new publicly available GEOS-5 simulation driven by the MERRA-2 reanalysis and including full stratospheric and tropospheric chemistry.

Bauer, Susanne

Can Semi-Volatile Organic Aerosols Lead to Less Cloud Particles?

The impact of condensing organic aerosols on activated cloud number concentration is examined in a new aerosol microphysics model, MATRIX-VBS. The model includes the volatility-basis set (VBS) framework coupled with the aerosol microphysical scheme MATRIX (Multiconfiguration Aerosol TRacker of mIXing state) that resolves aerosol mass and number concentrations and aerosol mixing state. By including the condensation of organic aerosols, the new model produces less activated particles compared to the original model, which treats organic aerosols as non-volatile. Parameters such as aerosol chemical composition, mass and number concentration, and particle sizes which affect activated cloud number concentration are thoroughly tested via a suite of Monte-Carlo simulations. Results show that by considering semi-volatile organics in MATRIX-VBS, there is lower activated particle number concentration, except in cases with low cloud updrafts, in clean environment at above freezing temperatures, and in polluted environments at high temperature (310K) and extremely low humidity conditions. We will examine these results also on the global scale and will show if the same results are seen when coupled with the GISS climate model GISS-E2.1.

Bhartia, Pawan

Recent progress in measuring stratospheric and tropospheric aerosols from space (key-note presentation)

Bian, Huisheng

Observationally constrained analysis of sea salt aerosol in the marine atmosphere

Sea salt is the largest contributor to atmospheric aerosol mass. Sea salt aerosol regulates marine cloud formation, provides a sink for reactive gases, and is a source of halogens to the atmosphere. We present a systematic and comprehensive global sea salt study by integrating NASA GEOS model simulations run with the GOCART aerosol module with ATom in situ measurements from the PALMS and SAGA instruments, as well as AOD measurements from AERONET Marine Aerosol Network (MAN) sun photometers and satellite observations over the oceans from MODIS. This study covers remote regions over the Pacific, Atlantic, and Southern Oceans, from near the surface to ~12 km altitude and covers both summer and winter seasons. Important atmospheric sea salt fields, e.g. mass mixing ratio, vertical distribution, size distribution, and marine aerosol AOD, are examined. Sea salt aerosol relationship to relative humidity and the simulation of emission, dry deposition, sedimentation, and large scale and convective wet deposition processes are explored to explain the observed sea salt fields and to reveal potential directions for model improvement.

Brown, Hunter

Improvement of Biomass Burning Aerosol Optical Properties in CAM5.4 and Comparison of AeroCom Model Optical Properties to Observations

Improvements to biomass burning (BB) aerosol optical properties in NCAR Community Atmosphere Model version 5.4 (CAM5.4) and validation of Phase II AeroCom models highlight disagreements between modeled and observed BB optical properties. One aspect of this work addresses the improvement of biomass burning aerosols in CAM5.4 through the addition of absorbing primary organic aerosols (i.e., brown carbon (BrC)). This implementation results in a global mean BrC radiative effect due to aerosol-radiation interaction (REari) of 0.13 W m-2, which reduces to 0.06 W m-2 when a photochemical bleaching effect is included. While the addition of BrC improves the model representation of the absorption Angstrom exponent (AAE), BB regions in the model underestimated single-scattering albedo (SSA) when compared to AERONET observations. This underestimation is present in the default CAM5 model, and is consistent with further comparison of observations to CAM5. When similar comparisons are conducted with HadGEM2, GISS-ModelE, OsloCTM2, and CAM5.1-MAM3 there are some consistencies in model underestimation of SSA. However, there are also unexpected disagreements that indicate a need to address the optical properties, size distribution and the composition of BB aerosols in these models.

Burgos, Maria

Comparison between in-situ surface measurements and global climate model outputs of particle light scattering coefficient as a function of relative humidity

Ambient aerosol particles can take up water and thus change their optical properties depending on their hygroscopicity, their size, and the relative humidity (RH) of the surrounding air. Knowledge of the hygroscopicity effect is of importance for radiative forcing calculations but is also needed for the evaluation of remote sensing and model results with in-situ measurements. The dependence of particle light scattering on RH can be described by the scattering enhancement factor f(RH), which is defined as the particle light scattering coefficient at a given RH divided by the scattering coefficient at dry conditions (see e.g. Titos et al., 2016). In this study, f(RH) measurements performed at 26 sites - with a wide global coverage and representing a variety of aerosol types - have been re-analyzed and harmonized to provide a benchmark dataset. Most of the stations which provided data are part of active measurement networks such as ACTRIS or NOAA. An identical data treatment process has been applied to all measurements and data quality has been assured by a thorough inspection of each dataset. The ultimate goal of this AeroCom project is to assess how well global models simulate the aerosol/water interaction using in-situ measurements of aerosol hygroscopicity. In this study, we show for the first time a comparison between our in-situ benchmark dataset for aerosol hygroscopicity and output from two models (GEOS5-MERRAero and CAM5.3-Oslo). Modelled and measured scattering enhancement factors are compared for various sites that are representative of a range of aerosol types. First results show distinct consistencies (e.g., for a dust-dominated site) and inconsistencies (e.g., for several Arctic sites) that will be further discussed in the presentation and indicate that this approach shows potential for constraining simulations of aerosol/water interactions.

Chin, Mian

AeroCom and ACAM - we share not only the common letters but also the common interests

What is ACAM? Why is it important? How can AeroCom and ACAM help each other? What AeroCom model experiments/analysis can benefit both? - let's find out...

Ciren, Pubu

NOAA JPSS Enterprise Aerosol Detection Product

Remote sensing from space provides an unprecedented capability to monitor the spatial and temporal variability of aerosol event including smoke and dust outbreak. NOAA JPSS Enterprise Aerosol Detection algorithm was developed to detect Aerosol Type including smoke and dust, based on the distinct spectral signature of dust in both deep-blue and IR wavelengths. The JPSS Aerosol detection algorithm has been applied to Suomi NPP VIIRS observations since 2001 and to NOAA-20 VIIRS observations since 2018. In this paper, we will present the overview of JPSS Enterprise Aerosol Detection product, including algorithm development, validations against CALIOP VFM product and AERONET observations, and examples of application of JPSS ADP product in tracking various smoke and dust events, such as transatlantic dust transport and smoke outbreak from Canadian/US fire events.

Colarco, Pete

Toward a Sectional Aerosol Representation in the NASA Goddard Earth Observing System (GEOS) Model

The NASA Goddard Earth Observing System (GEOS) global Earth system model supports various aerosol and chemistry modules. For example, for high spatial resolution forecasting activities we have long relied on the Goddard Chemistry, Aerosol, Radiation, and Transport (GOCART) bulk aerosol module. Toward an improved representation of aerosol microphysics and composition we have implemented the Community Aerosol and Radiation Model for Atmospheres (CARMA), developed jointly by NCAR, the University of Colorado, and NASA. CARMA has been coupled to radiation and chemistry in GEOS for, variously, dust and sea salt and volcanic sulfate related simulations. In this presentation we discuss progress to a more complete representation of aerosol species in GEOS using the sectional CARMA scheme, including the addition of carbonaceous aerosols and accounting for internal mixing. We report on performance and model tuning considerations, and highlight outstanding issues, such as needed mechanisms for nitrates and an improved coupling to radiation and chemistry schemes.

Cohen, Jason

Modeling of Polluted Aerosol Conditions: Quantifying Emissions and Improving Physical Understanding using a New Co-Variability Approach across Multiple Satellites, Models, and Measurements

Remotely sensed observations reveal global trends and variation in aerosols. This forms a basis for determining when an event is abnormally intense, or uniquely distributed in space and time. Using multiple related measurements from multiple sensors, starting from 2006 to the present, allows for more information based on different chemical lifetimes of aerosols and related co-emitted species. We have developed multiple new sets of emissions based on this approach. We then use these new emissions as well as standard emissions datasets to compute the modeled aerosol loadings and surface concentrations over the past 12 years. Comparisons are made across different emissions profiles and different physical and chemical schemes (all within the same model environment). Comparisons are made with measurements, including co-variability in both the spatial and temporal distribution of these magnitudes, across related some aerosols and trace gasses. Model variability associated with different chemical and physical lifetimes of these different species, allows for us to infer long-range transport and and in-situ processing under specific conditions. Under highly polluted conditions, the amount of BC and inorganic aerosol can frequently be optimized using the new approach, with robust results across Asia, Africa, South America, and biomass burning events in North American and Europe. Overall however, the results are not significantly improved for urban regions in North America and Europe. There seems to be little to no improvement over Japan. This approach provides a new perspective into where current emission databases can be and should be improved, and what types of physical and chemical process also should be addressed. Our initial findings are that first, there are aerosol sources from regions previously thought to have no sources; second that urban emissions regions tend to spread more in space; third that vertical rise and subsequent transport is significant; and fourth that transported and in-situ aged aerosols are important even in urban areas.

Deaconu, Lucia

Bounding aerosol properties and radiative effects using observations

Atmospheric particles play an important role in the global climate system as they can modify the Earth's radiative budget and cloud optical and microphysical properties. Despite improved knowledge on aerosol properties, substantial developments in global aerosol modelling (Textor et al, 2006; Mann et al, 2013) and better in-situ and remote observational methods, the uncertainties of the aerosol direct radiative effects from model estimates remain high (Schulz et al, 2006; Myhre et al, 2013), with global mean aerosol radiative forcing ranging between 0 and -2 W m-2 (Boucher et al., 2013). The A-CURE project aims to understand and quantify the uncertainty in how changes in anthropogenic aerosols affect climate through the development of a perturbed parameter ensemble (PPE) of 27 parameters, varying from emissions and processes related to aerosols and clouds to radiation and atmospheric dynamics. In this study we work towards reducing the uncertainty of the aerosol radiative forcing estimated from HadGEM3-UKCA climate model using remotely sensed observations. In preparation for this analysis we first evaluate the baseline estimates of aerosol optical thickness (AOT) and absorption with remotely sensed observations, on a global and regional scale. We consider two satellite aerosol retrievals based on the passive POLDER/PARASOL and MODIS instruments, and one active method based on the space-borne lidar CALIOP. Each sensor has its own characteristics leading to different ways of retrieving aerosol properties and to different accuracies in these retrievals. This translates into a more robust assessment of the model-observation sampling errors, which are essential for model constraint. Measurements from different sites of the AERONET sun-photometer network are used to evaluate and quantify the model simulations and satellite observations on a local scale. Additionally, we analyse high-temporal resolution aerosol direct radiative effect (DRE) (W m-2) on a global scale and over different regions, selected for their specificity in aerosol type, which emphasizes how different aerosol properties lead to uncertainties in the global annual mean top-of-atmosphere (TOA) forcing estimates.

Descloitres, Jacques

A validation tool for satellite aerosol data sets

Comparing ground-based measurements to geophysical variables retrieved from satellite observations is the basis of most cal/val studies. Moreover, intercomparison exercises of satellite data sets often rely on one-to-one comparisons to reference ground-based data sets, because of the complexity of direct intercomparison of satellite data sets when instrumental characteristics, viewing geometry, spatial and temporal resolution, orbiting pattern, etc. are different. While satellite data sets and reference data sets are usually well identified, most studies use a specific subset (temporal and spatial) of those and apply some specific collocation scheme to produce match-up data sets. Publications often emphasize validation results while providing little documentation about the collocation process that often lacks traceability, which makes it hard to reproduce. In this context, the ICARE Data and Services Center developed a tool to support validation and intercomparison of aerosol satellite products. It supports several standard satellite data sets archived at the ICARE data center (e.g., MODIS, PARASOL, AATSR, MERIS, SEVIRI) and co-locates them with AERONET observations. ICARE ensures full traceability of all input data sets, which can also be accessed directly by any user once registered. Optimized data processing allows on-demand retrieval of collocated data sets over long time periods. Input data sets and optional subsetting options (geographic area, time period, subset of ground stations, coastal filter, etc.) can be selected through a web-based interface. Collocation criteria (sampling distance to AERONET sites and sampling time window) are tunable. A major advantage of centralizing such a tool in one facility is to apply exactly the same collocation scheme to various data sets with adequate traceability. Also it saves significant data handling effort when repeating match-up retrievals for several input data sets and/or collocation parameters. Users can easily reproduce a given match-up retrieval. Finally, ICARE makes this tool available to algorithm developers who want to submit experimental data sets to the same validation bench as standard data sets.

Espinosa, Reed

Airborne classification of aerosols over the contiguous United States: an in situ light scattering perspective

Type specific assumptions regarding aerosol radiation interactions are essential for models used to estimate climate change and interpret remote sensing observations. The Polarized Imaging Nephelometer (PI-Neph) made extensive measurements of aerosol phase function (P11) and degree of polarization (-P12/P11) over the contiguous United States during the Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) and Deep Convective Clouds and Chemistry (DC3) field experiments. In this work, principal component analysis (PCA) is used to reduce the dimensionality of these multi-angle scattering measurements and the possibility of determining the predominant particle type from the resulting PCA scores is explored. Strong correlations are found between the PCA results and an independent aerosol classification scheme utilizing measurements of trace gasses, chemical composition, aerodynamic particle size and geographic location. The unique scattering patterns that reliably distinguish the individual aerosol types are found to be quite subtle and often rely on relationships between many scattering angles simultaneously. This result emphasizes the value of multi-angle measurements, as well as principal component analysis's ability to reveal the underlying patterns in these datasets. Additionally, inversions are performed with the Generalized Retrieval of Aerosol and Surface Properties (GRASP) in order to explore the variations in fundamental particle properties driving the scattering differences found between the different aerosol types. The retrieved parameters suggest large quantities of dust aerosol in samples associated with convective systems as well as an elevated real and imaginary refractive index in biomass burning emissions.

Ferrare, Richard

Biomass Burning Aerosol Distributions over the Southeastern Atlantic Ocean measured by CALIOP and the NASA LaRC airborne High Spectral Resolution Lidar-2

We use both CALIOP satellite and NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidar 2 measurements to characterize biomass burning aerosol layers located over the Southeastern Atlantic Ocean. The HSRL-2 measurements were collected during the NASA EV S Observations of Aerosols above Clouds and their Interactions (ORACLES) missions in 2016 and 2017. HSRL-2 measured profiles of aerosol backscattering, extinction and aerosol optical depth at 355 and 532 nm and aerosol backscattering and depolarization at 1064 nm and so provided an excellent characterization of the widespread smoke layers above shallow marine clouds. We compute aerosol extinction and backscattering profiles for these layers from CALIOP attenuated backscatter data that are constrained by the CALIOP above cloud aerosol optical depth (ACAOD) using the return signals from the underlying clouds. These profiles provide more accurate ACAOD values and aerosol extinction profiles than the CALIOP V4 operational retrievals. During the July-October period in 2015-2016, these CALIOP profiles show that mean extinction values (532 nm) in the 300 m layer directly above the underlying clouds were above 0.020 km 1 about 55% of the time and above 0.050 km-1 nearly 20% of the time. These values decreased moving westward from the African coast. The HSRL-2 mean aerosol extinction profiles acquired during 2017 show considerably higher aerosol extinction just above the cloud top than profiles from the 2016 ORACLES deployment. In some cases, the HSRL-2 profiles also show vertical variability in aerosol intensive properties indicating changes in aerosol properties such as particle size. The HSRL-2 backscatter and extinction profiles are being used alone and in combination with airborne polarimeter measurements to reveal more detailed information about the vertical structure and the optical and microphysical properties of these extensive smoke layers.

Gao, Chloe

The Impact of Organic Aerosol Volatility on Aerosol Microphysics for Global Climate Modeling Applications

We examined the impact of organic aerosol volatility on aerosol microphysics using a newly developed model, MATRIX-VBS. The model, which can be used as a box model or a module in a global model, includes the volatility-basis set (VBS) framework in an aerosol microphysical scheme MATRIX (Multiconfiguration Aerosol TRacker of mIXing state) that resolves aerosol mass and number concentrations as well as aerosol mixing state. Results from the box model show that by including the condensation of organic aerosols, under most meteorological and environmental conditions, the new model (MATRIX-VBS) has less activated particles compared to the original model (MATRIX), which treats organic aerosols as non-volatile. Implemented in the global model GISS ModelE as a module, it is currently evaluated against observations and existing aerosol microphysical schemes in ModelE. We expect it to offer us valuable insights on how the addition of organics partitioning to aerosol microphysics would affect cloud microphysics in the global atmosphere and its implications for climate.

Garay, Mike

The MISR Version 23 Operational Aerosol Products Over Land and Ocean

The Multi-angle Imaging SpectroRadiometer (MISR) project has recently completed reprocessing of the entire mission dating back to March 2000 with the latest version (Version 23) of the operational aerosol product. This product, provided in NetCDF-4 format at 4.4 km spatial resolution, replaces the previous 17.6 km resolution Version 22 HDF4-EOS product. Version 23 also includes simplified content and an improved estimate of per-pixel retrieval uncertainty over Dark Water. We will describe the key changes in Version 23 relative to Version 22 and show comparisons with AERONET sunphotometer data.

Ginoux, Paul

Anthropogenic Dust Experiment: Preliminary results

Agricultural practice has been the key factor of the infamous Dust Bowl of the 1930s (Lee and Gill, 2015), and through positive feedback may have amplified the drought in the Midwest (Cook et al., 2008). There are widespread evidence of wind erosion from anthropogenic emissions from cropland and pasture, but its contribution to global emission is highly uncertain. Model based estimations vary from negligible to 60% globally. Satellite based estimation is around 25% (Ginoux et al., 2012). But in this last study, the contribution to dust emission from agriculture is determined by distinguishing locations where landuse fraction of pasture and cropland greater than 30%, based on HYDE-2 database (Klein Goldwijk, 2001). Considering the potential impact of agricultural dust on air quality and climate, and the current uncertainty in term of its emission, transport, deposition and forcing, it was proposed to the AeroCom community an "Anthropogenic Dust Experiment". The concept of this experiment is to simulate 3 years (2010-2012) of dust distribution using a common inventory of agricultural dust sources based on Ginoux et al. (2012), and by varying the threshold of wind erosion over land use, which is poorly constrained by data. The results from 3 models will be presented, and the results discussed in view of the recent release of HYDE 3.2 land use inventory showing significant changes compare to the previous version (HYDE-2) used in this experiment.

Hasekamp, Otto

Aerosol Measurements from the NASA PACE mission

The NASA Phytoplankton Aerosol Cloud & ocean Ecosystems (PACE) mission will provide a quantum leap in aerosol observation capabilities from space. PACE will carry 3 instruments: 1) the Ocean Color Instrument (OCI) that provides hyperspectral measurements from the UV to the NIR (320-870 nm) + 6 SWIR bands. OCI is a wide swath single viewing angle instrument with very high radiometric accuracy and Signal to Noise Ratio (SNR). The spatial sampling is 1 km. 2) The SPEXone instrument that provides hyperspectral radiance and polarization measurements in the spectral range 385-770 nm observing each ground pixel under 5 viewing angles. SPEXone is a narrow swath instrument with very high polarimetric accuracy - important for aerosol retrieval - and a spatial sampling of ~2.5 km. 3) The Hyper-Angular Rainbow Polarimeter-2 (HARP-2) that provides hyper-angular radiance and polarization measurements at 4 wavelengths (440, 550, 670, 865 nm) observing a ground pixel under up to 60 viewing angles, enabling to resolve the cloud bow in polarization. HARP-2 is a wide swath instrument with a spatial sampling of ~2.5 km. The synergetic use of these 3 instruments will provide unprecedented information on a.o. aerosol absorption (SSA), aerosol amount (AOT, number column), aerosol type (through complex refractive index and particle shape) and size in both cloud free scenes and scenes where aerosol is located above clouds. In this presentation, we will discuss the aerosol capabilities of the PACE mission based on retrieval simulations and measurements of airborne campaigns that provide proxy data sets of the polarimeters to be flown on PACE (e.g. ACEPOL). The focus will be on the SPEXone polarimeter and we will discuss the synergetic use with OCI and HARP-2 to extract the full information that PACE contains. With algorithm developments still in an early phase it is important to get feedback from the AEROCOM community about their specific needs in terms of aerosol data products.

Holben, Brent

AERONET-from 1 to 600 (key-note presentation)

Ickes, Louisa

Arctic climate responses to mid-latitude aerosol emissions: Investigating the role of meridional heat transport and local cloud characteristics.

Previous studies using the Earth system model NorESM have shown that changes in aerosol particle emissions in various geographical regions in the northern mid-latitudes result in significant temperature responses in the Arctic. We aim to understand what triggers these polar temperature responses and which processes amplify the initial response. To this end, we present work looking into two aspects: Meridional heat transport through ocean and atmosphere and an assessment of Arctic clouds and aerosol population in the Northern high latitudes. To evaluate the role of ocean heat transport, we run a series of mixed-layer ocean experiments with NorESM, set up to replicate the aerosol forcing (atmospheric) and/or the ocean heat transport based on the different fully-coupled simulations. Preliminary results show that the large polar response can be replicated in the mixed-layer simulations by only modifying the aerosol forcing and not changing ocean heat transport. Much smaller responses are observed in the Arctic when the ocean heat transport is modified (to match the ocean heat transport values from the modified aerosol scenario) but no changes are made to aerosol forcing. This suggests the dominant role played by the atmosphere - either through atmospheric heat transport or local Arctic mechanisms, in triggering and/or amplifying the polar response. Considering local-scale mechanisms, long-wave cloud radiative effect in the Arctic region is lower in NorESM compared to remote sensing data (CERES) during polar twilight conditions and higher during boreal summer. Sensitivity tests aim at identifying the critical cloud and aerosol parameters in NorESM that could account for the discrepancies between observed and modelled cloud forcing. Results from both parts of this work have vital implications for the rate of modelled sea ice melt which is significantly smaller in NorESM compared to remote sensing observations (OSI-SAF) and could contribute to disentangling our understanding of Arctic Amplification.

Jethva, Hiren

A Global OMACA Product of the Optical Depth of Aerosols above Clouds: Results from 12-Year Long OMI Record

Aerosol-cloud interaction continues to be one of the leading uncertain components of the climate models, primarily due to the lack of an adequate knowledge of the complex microphysical and radiative processes of the aerosol-cloud system. The situations when aerosols and clouds are found in the same atmospheric column, for instance, when light-absorbing aerosols such as carbonaceous particles and/or windblown dust overlay low-level cloud decks, are commonly found in the several regions of the world. Contrary to the known cooling effects of these aerosols in cloud-free scenario over dark surfaces, the overlapping situation of absorbing aerosols over cloud can potentially exert a significant level of atmospheric absorption and produces a positive radiative forcing (warming) at top-of-atmosphere. The magnitude of direct radiative effects of aerosols above cloud directly depends on the aerosol loading, microphysical and optical properties of the aerosol layer and the underlying cloud deck, and geometric cloud fraction. We contribute to this topic by introducing a novel product of above-cloud aerosol optical depth (ACAOD) of absorbing aerosols retrieved from the near-UV observations made by the Ozone Monitoring Instrument (OMI) onboard NASA's Aura platform. Physically based on the strong 'color ratio' effect in the near-UV caused by the spectral absorption of aerosols above the cloud, the OMACA algorithm of OMI retrieves the optical depths of aerosols and clouds simultaneously under a prescribed state of the atmosphere. Here, we present the algorithm architecture and results from a 12-year global record (2005-2016) including global climatology of the frequency of occurrence of aerosol-cloud overlap and ACAOD. We will also show the validation results of OMACA retrievals conducted using the ORACLES-1 airborne measurements taken over the Southeastern Atlantic Ocean. Initial results on the regional estimates of aerosol radiative effects over clouds derived using OMI-CERES synergy will also be covered in the presentation.

Kayetha, Vinay

Characterization of UV-Visible aerosol absorption properties using combined satellite and ground measurements

In this research, we derive wavelength-dependent single scattering albedo (SSA) of aerosols UV to the visible range. Routinely made multi-spectral aerosol extinction measurements from ground-based Sun Photometers at the Aerosol Robotic Network (AERONET) sites are providing a valuable aerosol record for more than two decades now. Along with the direct measurements of aerosol optical depth, diffuse-sky radiance measurements made at the sites are used in an inversion procedure to retrieve aerosol particle size distribution and absorption properties. The AERONET inversion product is believed to be more reliable for the local morning-evening measurements owing to stronger aerosol signal at larger solar zenith angle. Local noon A-Train satellite measurements over the sites provide an opportunity to fill this gap. Objectives of the present research are two folds. Firstly, we derive aerosol absorption properties during local noon A-Train satellite overpasses over the sites. Secondly, we extend the retrieval of aerosol spectral absorption to the near-UV wavelengths where such inversion from AERONET is non-existent. We achieve this by using aerosol particle size distribution and real refractive index of AERONET product to create LUT (Look-Up-Table) radiances for a robust inversion. The satellite measured radiances, geometry, and AERONET AOD are provided as inputs to the inversion procedure to obtain single scattering albedo for a specific wavelength. We utilize the near-UV (340, 354, and 388 nm) and visible (466 and 646 nm) radiances measured by the Ozone Monitoring Instrument (OMI) and MODerate Imaging Spectrometer (MODIS), respectively, for the proposed inversion. The wavelength-dependent single scattering albedo of aerosols is derived for 96 sites distributed worldwide for which continuous, long-term AERONET measurements are available. The UV-Visible spectral dependency of SSA obtained from our application is consistent with previous studies. In comparison to the AERONET, our retrieved SSA for 40% (60%) of observations at 388 nm and 646 nm agrees within the absolute difference of 0.03 (0.05) at 440 nm and 675 nm respectively. The derived aerosol SSA data set provides a valuable addition to the existing aerosol absorption record from AERONET and helps to improve our understanding of aerosol properties.

Kinne, Stefan

Aerosol radiative effects with MACv2

Monthly global maps for aerosol properties of the MACv2 climatology are applied in an off-line radiative transfer model to determine aerosol radiative effects. Maps illustrate the global distributions of direct (presence) effects for today's total tropospheric aerosol as well as for component contributions. Also time-dependent maps for anthropogenic impacts are offered, where aside from direct effects also the aerosol indirect effects are addressed. Hereby, indirect effects were simulated via smaller cloud drop sizes due to extra anthropogenic aerosol by applying a general relationship for associations of satellite retrieval statistics. For anthropogenic aerosol - on average - indirect effects are relatively stronger at the top of the atmosphere (TOA), while direct effects are relatively stronger at the surface. For today's conditions best estimates yield at TOA -0.35 W/m2 in direct cooling and -0.65 W/m2 in indirect cooling and (due to a 1.1W/m2 warming of the atmosphere by the direct solar heating effects) -1.45W/m2 in direct cooling and a -0.65W/m2 in indirect cooling at the surface. In contrast to anthropogenic aerosol, larger natural aerosols contribute with an IR greenhouse warming, so that despite their relatively weaker solar absorption the global average TOA forcing efficiencies are similar: with ca -11W/m2/AOD at all-sky conditions and with ca. -24 W/m2/AOD at clear-sky conditions. On a global average basis, the singled out soot (BC) aerosol component contributes at TOA at +0.55W/m2 for all BC and between +0.25 to +0.45W/m2 for anthropogenic BC, depending on the anthropogenic definition, which is particularly uncertain for BC. The influence of anthropogenic uncertainty, mainly caused by the limited access to a pre-industrial reference, is much stronger for indirect effects (due to saturation) than for direct effects. The anthropogenic aerosol (TOA) forcing has not changed much over the last 30 year and is unlikely to change over the next 30 years, despite strong regional shifts. These regional shifts explain most solar insolation (brightening or dimming) trends that have been observed by ground-based radiation data.

Kim, Dongchul

Observations and Modeling of Asian and Northern Pacific Dust Sources and Transports

Dust is a globally predominant aerosol type that affects cloud formation, radiative flux, climate, human health, and vegetation. Although dust distribution and long-range transport over North Africa and the Northern Atlantic Ocean has been studied extensively, dust over Asia and the North Pacific Ocean is more challenging for both models and observations, as the region is more influenced by air pollution, cloud, and a generally weaker dust signal. This presentation will provide estimates Asian dust source strength and subsequent Northern Pacific transport, based on the combined analysis of satellite and ground-based remote sensing observations with a number of global aerosol models participating in the AeroCom inter-comparison.

Knobelspiesse, Kirk

Aerosol remote sensing with the upcoming NASA PACE mission

The NASA Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) mission, due to be launched in 2022-2023 into LEO, will contain three instruments of interest to the aerosol remote sensing community. The primary instrument is the Ocean Color Instrument (OCI), a 350nm-885nm hyperspectral imager with two day, 1km global coverage. OCI will also have seven discrete SWIR channels, and has high SNR and calibration fidelity required by the Ocean Color community. PACE requirements include the production of MODIS or VIIRS quality 'heritage' aerosol and cloud products, but the potential instrument capability exceeds those requirements. Additionally, two cubesat scale multi-angle polarimeters will be contributed to the PACE mission, and fly on the spacecraft alongside OCI. The Hyper-Angular Rainbow Polarimeter -2 (HARP2) is a wide field of view instrument with four polarization sensitive spectral channels and between 20-60 viewing angles. The Spectro-polarimeter for Planetary Exploration one (SPEXone) is a narrow swath, multi-angle polarimetric spectrometer (385-770nm) designed to make precise polarimetric measurements. Both instruments offer the capability for advanced aerosol retrieval algorithms, and synergy with OCI. We will describe the status of the PACE mission and its characteristics, our expectations for performance once launched, and the opportunity this mission presents for aerosol remote sensing.

Kokkola, Harri

Cloud activation in the presence of semi-volatile compounds

Aerosol removal processes largely dictate how well aerosol is transported in the atmosphere and thus the aerosol load over remote regions depends on how effectively aerosol is removed during its transport from the source regions. This means that in order to model the global distribution of aerosol, both in vertical and horizontal, wet deposition processes have to be properly modelled. However, in large scale models, the description of wet removal and the vertical redistribution of aerosol by cloud processes are often extremely simplified. Here we present a novel aerosol-cloud model SALSA, where the aerosol properties are tracked through different cloud processes. These processes include: cloud droplet activation, precipitation formation, ice nucleation, melting, and evaporation. It is a sectional model that includes separate size sections for non-activated aerosol, cloud droplets, precipitation droplets, and ice crystals. The aerosol-cloud model was coupled to a large eddy model UCLALES which simulates the boundary-layer dynamics. In this study, the model has been applied in studying the wet removal as well as interactions between aerosol, clouds, and semi-volatile compounds, ammonia and nitric acid. These semi-volatile compounds are special in the sense that they co-condense together with water during cloud activation and have been suggested to form droplets that can be considered cloud-droplet-like already in subsaturated conditions. In our model, we calculate the kinetic partitioning of ammonia and sulfate thus explicitly taking into account the effect of ammonia and nitric acid in the cloud formation. Our simulations indicate that especially in polluted conditions, these compounds significantly affect the properties of cloud droplets thus significantly affecting the lifecycle of different aerosol compounds.

Kuehn, Thomas

The Volatility Basis Set in ECHAM-HAM-SALSA

Secondary organic aerosol (SOA) has been recognized as an important climate forcer for quite some time, as it can make up a substantial part of the total atmospheric aerosol. However, the atmospheric processes leading to SOA formation are rather complex, which makes it difficult to correctly include SOA in global climate models. Biogenic SOA has recently attracted more attention both because of its potentially negative climate feedback in the future [Paasonen 2013] and because of the uncertainty it introduces to present day aerosol forcing due to its presence in the pre-industrial era [Carslaw 2013]. Here we introduce a volatility basis set (VBS) SOA scheme to ECHAM-HAM-SALSA, which accounts for both biogenic and industrial SOA precursors. The model is freely configurable concerning the amount of organic precursors and volatility classes. The model shows good agreement with observed of organic aerosol mass at many ground-based measurement stations. Compared to satellite retrievals, the inclusion of the VBS improves the AOD modelled by ECHAM-HAM-SALSA in regions where large amounts of organics are emitted.

Lee, Huikyo

How long should the MISR record be when evaluating aerosol optical depth climatology in climate models?

This study used the nearly continuous 17-year observation record from the Multi- angle Imaging SpectroRadiometer (MISR) instrument on the National Aeronautics and Space Administration (NASA) Terra Earth Observing System satellite to determine which temporal subsets are long enough to define statistically stable speciated aerosol optical depth (AOD) climatologies (i.e., AOD by particle types) for purposes of climate model evaluation. A random subsampling of seasonally averaged total and speciated AOD retrievals was performed to quantitatively assess the statistical stability in the climatology, represented by the minimum record length required for the standard deviation of the subsampled mean AODs to be less than a certain threshold. Our results indicate that the multi-year mean speciated AOD from MISR is stable on a global scale; however, there is substantial regional variability in the assessed stability. This implies that in some regions, even 17 years may not provide a long enough sample to define regional mean total and speciated AOD climatologies. We further investigated the agreement between the statistical stability of total AOD retrievals from MISR and the Moderate Resolution Imaging Spectroradiometer (MODIS), also on the NASA Terra satellite. The difference in the minimum record lengths between MISR and MODIS climatologies of total AOD is less than three years for most of the globe, with the exception of certain regions. Finally, we compared the seasonal cycles in the MISR total and speciated AODs with those simulated by three global chemistry transport models in the regions of climatologically stable speciated AODs. We found that only one model reproduced the observed seasonal cycles of the total and non-absorbing AODs over East China, but the seasonal cycles in total and dust AODs in all models are similar to those from MISR in Western Africa. This work provides a new method for considering the statistical stability of satellite-derived climatologies and illustrates the value of MISR's speciated AOD data record for evaluating aerosols in global models.

Levy, Robert

Developing an integrated climatology of global aerosol properties from a constellation of LEO and GEO satellite observations.

With new sensors and new algorithms, we have greatly increased the coverage and accuracy of this global dataset. Most of our knowledge has come from sensors in low-earth orbit (LEO) which observe a given point on Earth only once or twice per day. This limits our understanding of the aerosol diurnal cycle. Now that there are multiple advanced imagers in Geostationary (GEO) orbits, including the Advanced Baseline Imagers (ABI) on GOES platforms and the Advanced Himawari Imagers (AHI) on the Himawari platforms, we have the opportunity to observe aerosol throughout the daytime. Since the existing LEO (e.g. MODIS, VIIRS) and new GEO sensors (AHI, ABI) have similar spectral capabilities, we use similar algorithms on all sensors. Thus, we have a constellation of GEO and LEO sensors that observe aerosols globally each day, and regionally at high temporal resolution. Since we expect our product to be crucial for advancing applications of air quality, chemical transport and climate research, a main goal of our project is to package this combined GEO/LEO product in a manner that makes it easily accessible and thus useful for the research and applications communities.

Limbacher, James

A Pixel-Level Aerosol Retrieval Algorithm for Turbid, Shallow, and Eutrophic Waters

As aerosol amount and type are key factors required for remote-sensing retrievals of properties such as the surface albedo and water leaving radiance, the Multi-Angle Imaging SpectroRadiometer (MISR) can contribute to ocean color analysis despite a lack of spectral channels optimized for this application. Conversely, an improved representation of surface reflectance properties should improve retrieved aerosol results as well. Here, we present a new method to retrieve aerosol amount/type self-consistently with the spectral remote-sensing reflectance (Rrs), over any water surface (excluding sea-ice), using the MISR Research Aerosol Retrieval Algorithm (RA). Initial results (presented here) indicate that the new version of the RA is sensitive to AOD and aerosol type, even over bright turbid water with retrieved Rrs greater than 20%.

Lipponen, Antti

Can we improve the satellite retrievals of aerosol Ångström exponent over land?

The Ångström exponent of an aerosol distribution indicates the dominating size of the aerosol particles. The size distribution information of aerosols is important, for example, in determining the origin of the aerosol. In the current aerosol retrieval algorithms, the surface reflectance and other sources of uncertainty have limited the accuracy of the retrievals – especially that of the Ångström exponent over land. We have developed a new general post-process correction method for the aerosol retrieval algorithms that can be used to improve the accuracy of the retrieval of aerosol properties such as the Ångstöm exponent and aerosol optical depth (AOD). In addition to improving the accuracy of the retrievals, our approach also provides a new way to derive pixel-based uncertainty estimates for the retrievals. The method is based on the use of a machine learning algorithm that is trained to correct for the retrieval results after the actual retrieval has been carried out (i.e. in the post-processing phase). The training of the algorithm is carried out with the help of ground-based AERONET observations. The method is general and not restricted to any specific aerosol retrieval algorithm or sensor. We have tested the method using the MODIS Dark Target collection 6.1 retrievals over land. Our preliminary results show that the use of the method is capable of improving the accuracy of the Ångström exponent and AOD retrievals over land when compared to the AERONET observations. The results indicate that the MODIS satellite data may contain aerosol distribution information that was not fully utilized by the current retrieval algorithms but can now be taken into account and utilized by using efficient new computational methods.

Litvinov, Pavel (Pavlo Lytvynov)

New possibilities of classification and global aerosol sources identification with GRASP

Aerosol and surface characterization from space-borne remote sensing are closely related topics. Accurate aerosol retrieval is impossible without accurate surface reflection knowledge and vice versa. Nowadays simultaneous treatment of both problems is considered as powerful tool for advanced surface/ atmosphere characterization and monitoring. New possibilities for accurate and detailed retrieval of aerosol and surface properties are recently offered by the enhanced retrieval algorithms such as GRASP (Generalized Retrieval of Aerosol and Surface Properties), where statistically optimized inversion is combined with advanced forward models for description of aerosol and surface scattering. It has already been demonstrated that simultaneous aerosol/surface retrieval with GRASP algorithm from the space-borne instruments of moderate and coarse spatial resolution (PARASOL, MERIS, GOCI etc.) can provide accurate and detailed characterization of both aerosol and surface. Here, using GRASP retrieval from multi-angle photopolarimetric PARASOL measurements, we discuss possibilities and challenges of aerosol classification in multi-dimensional space of retrieved parameters. Using this classification we investigate correlation of aerosol types with surfaces properties both over land and ocean. It will be demonstrated how the new-found intrinsic relations can be used for global aerosol sources identification and aerosol transport tracking.

Liu, Hongqing

consistent algorithm science across satellite sensors for AOD Retrieval (key-note presentation)

Evaluation of NOAA VIIRS Enterprise Aerosol Optical Depth Product

NOAA Enterprise Aerosol Optical Depth (AOD) retrieval algorithm was developed for 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. The retrieval with the Suomi NPP VIIRS became operational since July 2017 and the products are available via NOAA Comprehensive Large Array-data Stewardship System (CLASS) near real-time. Evaluation of the retrieved AOD against the AERONET ground measurements were performed over various spatial and temporal domains. The results show that the performance of the high spatial resolution (0.75km) NOAA VIIRS Enterprise AOD product is comparable to that of MODIS and recommended for operational use in environmental monitoring and model applications.

Liu, Hongyu

Evaluation of aerosol wet deposition in the NASA GEOS Chemistry-Climate Model using lead-210

Wet deposition is the dominant sink for a whole suite of aerosols in the troposphere but model parameterizations of this process are highly uncertain, substantially contributing to large uncertainties in the simulated loadings and radiative forcing of aerosols. Here we evaluate and constrain aerosol wet deposition in the NASA Goddard Earth Observing System (GEOS) Chemistry-Climate Model (GEOS CCM) by simulating aerosol tracer lead-210 (210Pb). Lead-210 (radioactive half-life 22.3 years) is the decay daughter of radon-222 (222Rn, half-life 3.8 days), a radioactive gas emitted from continental crust. Lead-210 attaches immediately after production to ambient submicron aerosols and is subsequently subject to dry and wet deposition. Because of its relatively well-known sources and chemically inert nature with wet deposition as the principal sink, 210Pb is a useful tracer for testing wet deposition processes in a global model. Our simulation of moist transport and removal as part of the GOCART aerosol module includes scavenging in convective updrafts, midlevel entrainment and detrainment, and first-order rainout and washout from large-scale precipitation. We calculate the global budget and mean lifetime (against deposition, 6.7 days) of tropospheric 210Pb. We compare GEOS free-running simulations with climatological records of 210Pb concentrations and deposition fluxes at surface sites worldwide, and with the upper troposphere and/or lower stratosphere (UT/LS) 210Pb climatology constructed from ∼25 years of aircraft and balloon data. We conduct GEOS "replay" simulations and test the wet deposition parameterization against 210Pb profile measurements during eleven NASA airborne campaigns.

Liu, Yawen

Investigating model response to multi-decadal variations of aerosol emissions: the role of cloud and aerosol radiative effects

Long-term observations indicate that surface solar radiation (SSR) has shown decreasing or increasing trends in many regions of the world in the past several decades. Continuous efforts have been made on evaluating and understanding the model ability to simulate the trends of SSR from Coupled Model Intercomparison Project 3(CMIP3) to CMIP5. Despite advancements in model developments, many new-generation climate models still underestimate the magnitudes of trends and cannot simulate the correct signs of trends. While deficient emission data plays a crucial role in shaping the model response, large uncertainties also appear in simulated aerosol and cloud properties, both of which could affect simulated SSR and contribute to the uncertain model response to some extent. This work is to understand the model discrepancies in simulating the observed trends of SSR based on CESM2 simulations. Relative contributions of aerosol and cloud radiative effects on the trends are first assessed. After appropriately isolating the aerosol contribution, the model discrepancy is then analyzed from the aerosol perspective with a detailed comparison of simulated aerosol properties to in situ observations and satellite data.

Lund, Marianne

Constraints on black carbon lifetime inferred from a global set of aircraft observations

Accurate representation of vertical distribution is a key prerequisite for reduced uncertainties in the climate impact of black carbon (BC) aerosols, but remains challenging. Previous single- and multi-model studies have indicated that a global mean atmospheric BC residence time less than 5 days is necessary for reasonable agreement with observed vertical concentration profiles, resulting in an increased focus on tuning global BC lifetime to improve model skill. However, these studies focused on observations over the Pacific Ocean, often using temporally and spatially coarse model information. Here we compare simulated distributions sampled from model data at varying spatial and temporal resolution with an extensive dataset of aircraft measurements from flight campaigns over the past decade, in order to examine the validity of conclusions drawn in earlier model-flight intercomparisons when considering a broader geographical scope. We confirm a constraint on the global-mean BC lifetime of <5.5 days, but with significant regional differences. In the African outflow region over the South Atlantic, only a weak constraint can be placed on lifetime in our analysis. The choice of sampling methodology influences results, although generally without introducing major bias. Sampling coarser model data reduces the agreement, but sampling errors are mostly small compared to both the model error and inter-model variation.

Luo, Gan

Comparison of GEOS-Chem-APM and CAM-Chem-APM simulated cloud droplet number concentrations with MODIS retrievals

Cloud droplet number concentration (CDNC) is a key variable associated with aerosol indirect radiative effects which have large uncertainties and low level of understanding. CDNC depends on particle size and compositions as well as the cloud droplet activation and microphysics. In this study, we use the global chemical transport model GEOS-Chem and global climate-chemistry model CAM-Chem, both incorporated with the Advanced Particle Microphysics module (APM), to simulate global distributions of the mass, number, size, and mixing state of atmospheric particles and their activation into cloud droplet. We show that model simulated aerosol mass and number concentrations agree well with relevant measurements, in term of the absolute values as well as their spatial gradient. From detailed aerosol composition and size information from APM, CDNC is calculated at each grid box when there are cloud formation and dispersion, with cloud-borne aerosols explicitly tracked. To evaluate the model simulated CDNC, we have also derived global monthly mean CDNC for 2003-2016 from MODIS collection 6 daily cloud optical depth and cloud effective radius at 1.6 µm spectral channel from the Terra and Aqua platforms, following the approach described in previous publications. The comparison of satellite retrieved CDNC and model simulated CDNCs shows that their values and distributions are overall close to each other but large differences exist in some regions. Seasonal variations of CDNC from satellite retrievals and model simulations will also be presented.

Luffarelli, Marta

Aerosol properties retrieval with the CISAR algorithm applied to geostationary and polar orbiting satellite observations

CISAR (Combined Inversion of Surface and AeRosol) is a generic algorithm for the joint retrieval of surface reflectance and aerosol properties with continuous variations of the state variables in the solution space. CISAR is based on the inversion of a fast Radiative Transfer Model (RTM) in an optimal estimation framework, including prior information on the state variable magnitude and regularization constraints on their spectral and temporal variability. The observed scenario is described through two atmospheric layers and an underlying surface, radiatively coupled with atmospheric scattering. CISAR retrieves the surface reflectance model parameters, the aerosol optical thickness and single scattering properties in each processed wavelength. This study analyses CISAR algorithm performance when applied on actual satellite data acquired from different sensors, flying at different orbits. For this purpose, SEVIRI (geostationary) and PROBA-V (polar orbiting) observations acquired over 20 AERONET stations observed by both instruments during year 2015 have been processed. The concept of observation system will be first defined, including the characterization of all associated uncertainties. CISAR's retrieved surface and aerosol properties will be evaluated against MODIS land product and AERONET data respectively. The performance differences resulting from the two types of orbit are discussed, analyzing and comparing the information content of SEVIRI and PROBA-V observations.

Mallet, Marc

Simulation of the transport, vertical distribution, optical properties and radiative effect of smoke aerosols with the ALADIN regional climate model during the ORACLES1 and LASIC experiments.

In this study, we take advantage of the large number of observations acquired during the ORACLES1 and LASIC projects to study the radiative and climatic impacts of smoke particles during September 2016 with the ALADIN Climate regional model. Concerning stratocumulus clouds, our results indicate a good representation of the liquid water path (LWP) by ALADIN Climate, contrary to the low cloud fraction (LCF) which is largely underestimated. For biomass burning aerosols, AOD and Above Cloud AOD (ACAOD) are found to be consistent (~0.7 over continental sources and ~0.3 over SAO at 550 nm) with MERRA2, OMI or MODIS data. In terms of vertical structure, the simulations indicate a transport of smoke over SAO that mainly occurs between 2 and 4 km, consistently with surface and aircraft lidar observations. Single scattering albedo is found to be slightly overestimated over sources compared to AERONET but significant biases are identified when compared to Ascension Island surface observations. For September 2016, ALADIN Climate simulates a positive (monthly mean) SW DRF of about +6 W/m2 over SAO at the top of the atmosphere (TOA) in all sky conditions. Over the African continent, the presence of smoke is shown to significantly decrease the net surface SW radiations, which is compensated by a decrease in sensible heat fluxes and surface land temperature over Angola, Zambia and Congo notably. The association of the surface cooling and the lower tropospheric heating tends to decrease the continental planetary boundary layer (PBL) height over the continent.

Martins, Vanderlei

Using Small Satellite Constellations for the Measurement of Aerosol and Cloud Interaction

The advance of small satellites and, in particular, low cost Nano-Satellites with powerful science capabilities are allowing for new concepts involving satellite constellations that benefits from multiple vantage points of view, which allows for the optimized observation of cloud and aerosol events with unprecedented detail, temporal and spatial resolution. Although these assets are not yet available in space, the technology to measure detailed aerosol and cloud properties, and their interaction has been demonstrated from aircraft and is ready for prime time. In fact, some components of these

measurements have been implemented for CubeSat satellites and will soon fly in space. An example of this fact is the miniaturized HARP sensor which is scheduled for launch in a 3U CubeSat by the end of 2018. In addition to HARP, other Nano-Satellite sensors have been studied for the high resolution measurement of cloud microphysical properties including VNIR, SWIR, and TIR wavelengths. This work proposes a combination of these measurements in a constellation of small satellites that can sample the interaction between Aerosol and Clouds around the globe. Details of this constellation relies on inputs from the modelling community in terms of the temporal and spatial frequency required for these measurements.

Matsui, Hitoshi

Black carbon radiative effects highly sensitive to emitted particle size when resolving mixing-state diversity

Post-industrial increases in atmospheric black carbon (BC) have a large but uncertain warming contribution to Earth’s climate. Particle size and mixing state determine the solar absorption efficiency of BC and also strongly influence how effectively BC is removed, but they have large uncertainties. Here we use a multiple-mixing-state global aerosol microphysics model and show that the sensitivity (range) of present-day BC direct radiative effect, due to current uncertainties in emission size distributions, is amplified 5-7 times (0.18-0.42 W m-2) when the diversity in BC mixing state is sufficiently resolved. This amplification is caused by the lifetime, core absorption, and absorption enhancement effects of BC, whose variability is underestimated by 45-70% in a single-mixing-state model representation. We demonstrate that reducing uncertainties in emission size distributions and how they change in the future, while also resolving modelled BC mixing state diversity, is now essential when evaluating BC radiative effects and the effectiveness of BC mitigation on future temperature changes.

McBride, Brent

Wide field-of-view observations of aerosol and clouds from Hyper-Angular Rainbow Polarimeter (HARP) measurements

Comprehensive measurements that take advantage of multi-angle and multi-wavelength sampling, polarization, and dynamic spatial resolutions can accurately and widely characterize aerosol microphysical properties from space and aircraft. The Airborne Hyper-Angular Rainbow Polarimeter (AirHARP) and the HARP CubeSat satellite, both designed, developed, and deployed by the University of Maryland, Baltimore County (UMBC) Laboratory for Aerosol and Cloud Optics (LACO), are wide field-of-view imaging polarimeters capable of polarized measurements in 4 VNIR wavelengths and up to 60 unique view angles per wavelength. The main aerosol observations by AirHARP are prescribed smoke plumes during the Aerosol Characterization from Polarimeter and LiDAR (ACEPOL) campaign in 2017. Here we present a top-level analysis of how AirHARP's unique single-superpixel retrieval capability allows for the retrieval of aerosol and cloud microphysical properties in all portions of our field-of-view, and how this wide field-of-view extends and complements the measurements by other coincident polarimeters and radiometers. The AirHARP results will be discussed as an example of what we can expect from HARP CubeSat (planned for launch in 2018) and HARP2 for PACE that will launch in 2022.

McGraw, Zachary

Sensitivity study of mineral dust impacts on global clouds and climate

Airborne mineral dust acts as an important ice nuclei (IN) in cold cloud formation, with global influence on cloud physical and radiative properties. We use a global climate model (GCM), modified to make ice nucleation responsive to dustiness in tune with observations, to assess these influences in past and present climates. Attention is paid to the sensitivity of results to the efficiency of the Wegener-Bergeron-Findeisen (WBF) process representing ice crystal growth at the expense of cloud droplets, which has previously been found to be overestimated in most climate models.

Meskhidze, Nicholas

Using global aerosol types for improved assessment of aerosol direct radiative effect

Recent analyses of the Fifth Assessment Report of the IPCC and the CMIP5 have shown that aerosol direct radiative forcing is a large uncertainty in the Earth's radiative balance during the industrial era. As the uncertainty in aerosol radiative forcing translates into the uncertainty in climate sensitivity, there have been numerous appeals for the need to carefully re-examine aerosol forcing. One way to evaluate aerosol radiative forcing is through remote sensing. However, as satellite sensors do not easily discriminate anthropogenic from natural background aerosols, future progress in remotely sensed assessments of aerosol radiative forcing depends on models. Currently, models are tuned to represent aerosol optical depth (AOD) - a parameter for which global long-term measurements are available. Because of this, model-to-model representations of aerosol microphysics and refractive properties can be very different, yet still achieve good agreement with satellite retrieved column-averaged quantities. Therefore, it is difficult to determine which aerosol microphysics is the most accurate in representing the truth. Moreover, when using AOD values, models can only directly constrain the total (i.e., composition- and vertically-integrated) aerosol extinction while other properties (e.g., aerosol chemical composition and scattering) remain unconstrained. Model uncertainties could be reduced using 3-D global long-term measurement databases for aerosol size distribution, chemical composition, mixing state, and microphysical properties (complex refractive index, size distribution, density, etc.), though such measurements do not exist and will likely not be available in the foreseeable future. This talk will discuss a new methodology that could circumvent the existing difficulty of model-representation of aerosol microphysical information and take a step toward reducing the uncertainty in the aerosol radiative forcing. This is done by connecting aerosol types, similar to those retrieved through High Spectral Resolution Lidar (HSRL) (i.e., fresh smoke, smoke, urban, maritime, dusty-mix), with parameters needed in radiative transfer calculations (i.e., single scarring albedo, and asymmetry parameter). The aerosol types are generated using the CATCH (Creating Aerosol Types from CHemistry) algorithm with the model/reanalysis data of aerosol size distribution, chemical composition, and microphysical properties. For the specified aerosol chemical composition and AOD, we show that the uncertainty in single scarring albedo is generally smaller when aerosol types are used compared to the range in size distribution, morphology, density, and refractive index employed by the AeroCom models. Moreover, our calculations suggest that single scarring albedo and asymmetry parameter derived for different aerosol types are within the ranges reported in the literature. Since HSRL types are grounded in intrinsic aerosol optical properties and can be retrieved remotely, the proposed methodology may lead to improved model representations and reduced uncertainty of aerosol radiative assessments.

Michou, Martine

Météo-France aerosol-related AerChemMIP CMIP6 simulations : presentation and results

This poster will present the Météo-France CNRM-ESM2-1 Earth System model used for the CMIP6 AerChemMIP simulations, the simulations performed so far, and some diagnostics analyzed in-house. A focus will be made on results from the piClim simulations such as the piClim-2xss and piClim-2xfire simulations, from the histSST-piNTCF simulation, and from the ssp370-lowNTCF simulation. Météo-France CNRM-ESM2-1 Earth System.

Mie, Linlu

The recent progress of aerosol retrieval over the Arctic regions

In this talk, the recent progress of aerosol passive remote sensing over the Arctic regions under the support of the Arctic Amplification: Climate-Relevant Atmospheric and Surface Processes and Feedback Mechanisms (AC3) project will be presented. A new cloud screening utilizing a time-series technique has been successfully developed and the comparison with CALIPO and other ground-based measurements show that the accuracy of this algorithm is mature enough to be used as the pre-processing of the aerosol retrieval over the Arctic regions. The radiative transfer modeling through terrestrial atmosphere and snow/ice has been thoroughly investigated and a corrected path radiance representation of radiative transfer equation is used for the retrieval later. A new snow BRDF model in the frame of the Ross-Li model is also used. The first results with the new retrieval idea will be shown.

Mulcahy, Jane

Impact of natural aerosol emissions on the aerosol ERF in UK CMIP6 models

The latest generation UK Earth System model, UKESM1, is built on top of the core physical climate model, HadGEM3-GC3.1. Simulations from both of these physical and ES models will be submitted to CMIP6. Aerosol processes and, in particular, aerosol-cloud interactions cut across the traditional physical-Earth system boundary of coupled Earth system models and remain one of the key uncertainties in estimating anthropogenic radiative forcing of climate. UKESM1 extends the physical-dynamical model to also include key marine and terrestrial biogeochemical cycles and fully interactive stratospheric-tropospheric trace gas chemistry. Such additional Earth-system processes enable the inclusion of interactive emissions of a number of natural aerosol sources which are otherwise prescribed, including marine dimethyl sulphide (DMS), primary marine organic aerosol, mineral dust, and terrestrial biogenic volatile organic compounds (BVOCs). The pre-industrial aerosol climate will therefore differ between these two models. Here we investigate the impact of different representations of these natural aerosol sources on the aerosol effective radiative forcing (ERF) in HadGEM3-GC3.1 through incorporation of the interactive emissions from the fully coupled UKESM1. This work highlights the importance of constraining the background pre-industrial aerosol state in order to provide improved constraints on the anthropogenic aerosol forcing. The implications of including such interactions in Earth system models are discussed.

Myhre, Gunnar

Rapid adjustments of black carbon strongly dependent on vertical profile in multi-model simulations

A weak surface temperature response from black carbon (BC) in general circulation models have been quantified to be caused by a strongly negative rapid adjustment (Stjern et al., 2017). In four general circulation models a short lifetime of BC of around 3 days the direct aerosol effect and the rapid adjustment along with the surface temperature response have been quantified. The direct aerosol effect and rapid adjustments are both weaker for a short BC lifetime compared to a typical BC lifetime in AeroCom Phase II models. We use radiative kernels to quantify the individual contributions of temperature, water vapor, surface albedo and clouds changes to the rapid adjustment. All of these rapid adjustment terms changes with BC lifetime. The inter-model variation is large for the rapid adjustment of clouds, but also for changes in the tropospheric temperature. Independent of BC lifetime the surface temperature change in 100 years of fully coupled climate models simulations is weak.

Neubauer, David

Impact of future marine and shipping aerosol emissions in a warming Arctic

Projections of sea ice retreat in the Arctic show an ice free Arctic by the mid of the 21st century. We investigate the response of clouds and aerosol on Arctic sea ice retreat in summer and autumn using simulations with the global aerosol-climate model ECHAM6-HAM2 for the years 2004 and 2050. Furthermore, ship emissions will increase in an ice free Arctic due to transit cargo shipping or increased gas and oil extraction. A separate set of simulations with and without increased Arctic ship emissions is used to analyze their impact on aerosol and cloud radiative effects. Aerosol and clouds will cool more in 2050, mainly due to the decrease in surface albedo by the sea ice retreat (net cloud radiative effect changes from -36 to -46 Wm-2). Natural aerosol emissions will increase due to the larger ocean surface and clouds will become brighter (more cloud droplets, increased liquid water path) which leads to further cooling but these are secondary effects compared to the changes in aerosol and cloud radiative effects due to the surface albedo change. Increased Arctic ship emissions only have a relevant impact on radiative effect when an upper estimate of future Arctic ship emissions is used. Then they lead to more cooling (net cloud radiative effect changes from -48 to -52 Wm-2) due to brighter clouds (more cloud droplets, increased liquid water path).

MPI-ESM1.2-HAM: Evaluation of preliminary CMIP6 simulations

MPI-ESM1.2-HAM has been set up, tuned and evaluated preliminary and is therefore almost ready to be used in CMIP6 and AerChemMIP (the implementation of diagnostics is ongoing). For the preliminary evaluation, MPI-ESM1.2-HAM was compared to CMIP5 models and when possible to observations and re-analysis data. Pre-industrial control and historical simulations as well as future projections (using CMIP5 forcing) were evaluated and show in general a reasonable climate of MPI-ESM1.2-HAM. The present day climate (1979-2008) of MPI-ESM1.2-HAM is about 0.3 K colder than observed. The aerosol forcing between 1850 and 2008 in MPI-ESM1.2-HAM is -1.3 Wm-2 (the historic warming of MPI-ESM1.2-HAM shows a similar dependence on aerosol forcing as CMIP5 models). Atmospheric temperatures, surface pressure, wind speeds, radiative fluxes and cloud properties are close to the ones of the atmosphere-only model ECHAM6.3-HAM2.3 and agree reasonably well with observations and re-analysis data. The projected (RCP8.5) September Arctic sea ice change in MPI-ESM1.2-HAM is similar to the CMIP5 models which best represent present day Arctic sea ice.

Nowottnick, Ed

CATS Version 3 Aerosol Products and Retrievals of Aerosol Extinction and Surface Air Quality using the NASA GEOS AGCM

From February 2015 – October 2017, the NASA Cloud-Aerosol Transport System (CATS) backscatter lidar operated on the International Space Station (ISS) as a technology demonstration for future Earth Science Missions, providing vertical measurements of cloud and aerosols properties. Here, we present our level 2 aerosol products and that include improvements to cloud-aerosol discrimination and aerosol typing algorithms in our latest and final version 3 data reprocess. We additionally evaluate our latest level 2 aerosol products using the spaceborne Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) lidar (2006 – Present). Owing to its location on the ISS, a cornerstone capability of CATS was able to acquire, process, and disseminate near-real time (NRT) data within 6 hours of observation time. This capability served as motivation to develop a new 1-D ensemble-based (1-D EnsVar) retrieval technique that incorporates vertical profiles of total attenuated backscatter to produce vertically resolved estimates of speciated aerosol extinction, concentration and surface PM2.5 using the NASA Goddard Earth Observing System (GEOS) atmospheric general circulation model and assimilation system, which currently assimilates AOT from a number of passive sensors. The applications of this methodology provide a path forward to inform air quality forecasting models, and an effective way to improve estimates of surface PM2.5 concentrations from passive sensors. Here, we also present preliminary results and an evaluation of our 1-D EnsVar retrieval approach using independent observations from both space and ground-based platforms

Olayinka, Kafayat

Remote sensing climatology of cirrus cloud distribution within the United States

Cirrus cloud play an important role in the atmospheric energy balance and hence in the earth's climate system. The properties of optically thin clouds can be determined using both active and passive instrument. We retrieve measurements of the direct solar beam transmittance from the MultiFilter Rotation Shadowband Radiometer (MFRSR). With CALIOP L2 cloud layer backscattering product, we were able to derive few thin cloud optical properties. The accuracy of cloud optical properties determined from MFRSR is compromised by contamination of the direct transmission by light that is scattered into the sensors field of view; which Min et al., 2004 developed an algorithm using forward scattering correction method to improve the accuracy of thin cloud retrievals from MFRSR. In this study, we do statistics studies on cirrus clouds properties based on multi-years cirrus cloud measurements from MFRSR and CALIPSO at few ARM sites and HUBC site. The site locations include South Great Plain, and North Slope of Alaska regions. Our result shows over 30% of cirrus cloud present in the atmosphere are within optical depth between (1-2). We also found the average seasonal variation of thin COD during summer is ~ 2. Through the statistic studies, temporal and spatial variations of cirrus clouds are investigated.

Xiaohua Pan

Multiple Global Biomass Burning Emission Datasets: comparison and application in one global aerosol model

Wildfires and other types of biomass burning affect most vegetated parts of the globe, contributing ~40% of the annual global atmospheric loading of carbonaceous aerosols, as well as significant amounts of numerous trace gases. However, fire emissions are poorly constrained in global and regional models, resulting in high levels of uncertainty in understanding their real impacts. In this study, we evaluated five global biomass burning emissions datasets in terms of aerosol, namely: (1) GFEDv3.1 (Global Fire Emissions Database version 3.1); (2) GFEDv4s (Global Fire Emissions Database version 4 with small fires); (3) FEERv1 (Fire Energetics and Emissions Research version 1.0); (4) QFEDv2.4 (Quick Fire Emissions Dataset version 2.4); (5) Fire INventory from NCAR version 1.5 (FINNv1.5). In general, the spatial patterns of biomass burning emissions from these inventories are similar, although the magnitude of the emissions can be noticeably different. The emissions from the top-down approach-derived inventories QFEDv2.4 and FEERv1 are higher than the other three using bottom-up approach in most regions. The global organic carbon (OC) emissions in 2008 are 51.93 Tg, 28.48 Tg, 19.48 Tg, 15.65 Tg and 13.76 Tg, from QFEDv2.4, FEERv1, FINNv1.5, GFEDv3.1, and GFEDv4s, respectively. In general, higher emissions are estimated from the top-down approaches, QFEDv2.4 and FEERv1, are a factor of 2-3 larger than the rest bottom-up based BB datasets. QFEDv2.4 is the highest globally and in most regions. The five BB datasets less disperse in the major biomass-burning regions, Africa and South America, while more disperse over less burned regions. After implementing these different emission datasets to one global model, NASA Goddard Earth Observing System Model, Version 5 (GEOS-5), we evaluated the simulated aerosol optical depth (AOD) against those from AERONET and MODIS in different regions during 2008. In southern hemisphere Africa and South America, seemingly, the dataset QFED2 and FEER1 are the closest to the observation.

Patadia, Falguni

Pixel Level Uncertainties in the MODIS Dark-Target AOD Retrievals: Updates

The MODIS DT algorithm makes standard retrievals of aerosol optical depth over land and ocean at 10 and 3 km spatial resolution. We have identified 5 known sources of uncertainty in the retrievals over ocean and adopted a jacobian scheme to estimate per-pixel level uncertainty in the 10km AOD product. We will briefly discuss the method, present a comparison of uncertainties in the product over different retrieval scenes and an evaluation of the pixel-level uncertainty of select AERONET sites. We will discuss the limitations of this method and the potential uncertainty from retrievals in the vicinity of clouds.

Petrenko, Mariya

Results from the AeroCom Biomass Burning Emissions Experiment: Satellite Constraints on Fire Emission Source Strength and Plume Injection Height

The combination of source strength and injection height is used to characterize aerosol sources in chemical transport, climate, and air quality models. Currently, a wide range of poorly constrained or unconstrained assumptions is used to represent the amount and vertical distribution of fire emissions. The AeroCom multi-model Biomass Burning (BB) experiment aims to put biomass burning aerosol emission parameterizations on firmer ground, by applying global constraints on source strength and injection height from MODIS and MISR satellite observations. We will present the results of BB experiment Phase 1 (source strength) and key results of the Phase 2 (injection height) effort. Phase 1 of the BB experiment involves comparing MODIS AOD snapshots with 14 AeroCom model ensemble runs, initialized using multiples of the daily GFED3 emissions, to help constrain smoke source strength. New results are based on several recent advances in the approach: (1) the expanded database of cases, with over 900 (over 400 in the AeroCom benchmark year 2008), and refined MODIS data processing to (2) fill in missing retrievals using scaled model results and (3) estimated background AOD subtracted from the plume observations, and (4) fire sources too small to be included in GFED3, based on the GFED4.1s inventory [Petrenko et al., JGR 2017]. Burning regions form four distinct groups: (1) Large fires mainly in boreal forests, (2) Intermediate fires requiring some source-strength adjustment, (3) High Background Aerosol regions, where the method of constraining smoke source strength tends to fail, and (4) regions dominated by Small Fires. With the help of participating modelers, we will summarize the statistical analysis of the 14-model Phase 1 results with GFED3 [Petrenko et al., 2018, to be submitted]. For Phase 2 of the BB experiment, we have developed a plume-height parameterization from statistical summaries of worldwide, region-specific, multi-year MISR plume height stereo retrievals [Val Martin and Kahn, 2018, in preparation]. The parameterization consists of fire emission fractions based on plant functional types or land cover units, and is stratified by altitude, region, biome type, and season. The climatology has been used in the CAM-Chem, GEOS-Chem, and HySPLIT models. We will present the climatology and preliminary model results. The parameterization will be available for testing with other models as part of BB Phase 2 experiment, and we will discuss plans for a coordinated AeroCom plume-height effort.

Povey, Adam

Quantifying the impact of industrial emissions on clouds

One of the greater uncertainties in climate observation and modelling is the means by which aerosols interact with clouds. Many mechanisms have been observed and theorised, producing both positive and negative radiative effects. However, the relative real-world importance of these is unclear, which complicates the parametrization of cloud processes within models. This presentation will outline a technique to quantify the variation of cloud micro- and macro-physical properties as a function of aerosol loading. Satellite observations of localised aerosol sources, such as industrial areas or volcanoes, are used as a natural laboratory where fresh aerosols are injected into an otherwise homogeneous field. Perturbed and pristine conditions can be separated by aligning the retrievals with the wind vector. The first indirect aerosol effect is clearly observed, with weaker evidence for cloud invigoration. Liquid water path effects are observed in some circumstances.

Pu, Bing

Retrieving global distribution of threshold of wind erosion from satellite data

Dust emission is initiated when surface wind velocities are greater than the threshold of wind erosion. Most dust models used constant threshold values globally. Here we use satellite products to constrain the frequency of dust events and surface characteristics. By matching this frequency derived from Moderate Resolution Imaging Spectroradiometer (MODIS) Deep Blue aerosol products with surface winds, we are able to retrieve a climatologically monthly global distribution of wind erosion threshold over dry and non-vegetated surface. This monthly two-dimensional threshold is then implemented in a Geophysical Fluid Dynamics Laboratory coupled land-atmosphere model (AM4/LM4). It is found that the climatology of dust optical depth (DOD) and total aerosol optical depth, surface PM2.5 and PM10 dust concentrations, and seasonal cycle of DOD are better captured over the “dust belt” (i.e. North Africa and the Middle East) by simulations with the new wind erosion threshold than those with the default globally constant threshold. Simulations with time-varying wind erosion thresholds also perform better than a constant annual-mean wind erosion threshold, as the latter overestimates DOD and surface dust concentrations in local dusty seasons. This global threshold of wind erosion can be retrieved under different resolutions to match the resolution of dust models and may improve the climatology and seasonal cycle of dust simulation as well as dust forecasting.

Puthukkudy, Anin

Measurements of Microphysical and Optical Properties of Volcanic Ash

Volcanic ash suspended after an eruption affects Earth’s shortwave and longwave radiative transfer budget, air quality, and aviation safety. Even though the lifetime of volcanic ash particles is significantly short compared to sulfate aerosols formed from volcanic eruptions, volcanic ash particles have the potential to cause a variety of important effects in the atmosphere. It is important to recognize that newly deposited volcanic ash is easily re-suspended to the atmosphere for months, years, or decades after a volcanic eruption. Thus, effective monitoring of volcanic ash after the eruptions is essential. Ash dispersion models along with satellite remote sensing observations are the best tool available to forecast the volcanic ash transport. However, a priori knowledge of the microphysical and optical properties of volcanic ash is needed for these tools to be effective and accurate. Presented here is a laboratory technique that uses a system to re-suspend the volcanic ash and couple it with mass, spectral absorption, and polarimetric measurements of the spectral and angular scattering to retrieve microphysical and optical properties of volcanic ash. A Polarized Imaging Nephelometer (PI-Neph) is used for measuring angular light scattering and polarization of the re-suspended particles from 3º to 175º in scattering angle, with an angular resolution of 1º. Primary measurements include phase function and polarized phase function at three wavelengths (445nm, 532nm, and 661nm). Size distribution, sphericity, and complex refractive index are retrieved indirectly from the PI- Neph measurements using the GRASP (Generalized Retrieval of Aerosol and Surface Properties) inversion algorithm. The resuspended ash particles collected on a Nuclepore filter is imaged using a Scanning Electron Microscope (SEM) to derive the particle size and shape distribution. A reflectance measurement setup is used for the measurement of mass absorption efficiency of particles in the wavelength range 300-1100nm. We report the results of this method applied to the ash samples from Mt. Okmok (2008), Novarupta (1912), Mt. Spurr(1992), Mt. Eyjafjallajökull (2010), Mt. Pinatubo (1991), Volcán de Fuego (2012) and Mt. St. Helens (1982) eruptions

Remer, Lorraine

The PACE mission: Focus on aerosols and clouds

NASA’s Plankton, Aerosol, Cloud, ocean Ecosystems (PACE) mission is under development and advancing quickly towards a launch in 2022. The primary instrument on this mission is the Ocean Color Instrument (OCI), a broad spectrum hyperspectral radiometer that offers new capability for aerosol and cloud characterization. OCI will be supported by two small contributed multi-angle polarimeters that provide highly complementary capabilities for new science possibilities. In particular, the Hyper-Angle Rainbow Polarimeter -2 (HARP2), contributed by the University of Maryland Baltimore County (UMBC) will be able to provide 2-day global coverage of advanced aerosol retrievals over land and ocean, and apply its hyperangle capability for characterization of cloud microphysics. HARP2 is based on two predecessor instruments, HARP Cubesat – a standalone single-sensor space craft and AirHARP, an airborne version of the HARP sensor.

Samset, Bjorn

Aerosol absorption: Why is it so hard to constrain?

Some aerosols absorb solar radiation. By removing energy from incoming sunlight and depositing it in the atmospheric column, this process can alter cloud properties, affect circulation, dynamics, and the water cycle. Aerosols contribute to surface and top-of-atmosphere radiative forcing, thereby altering the atmospheric energy balance and affecting surface and atmospheric temperatures. To understand the total (natural and anthropogenic) influences of aerosols on the climate, it is therefore crucial to constrain both their global and regional shortwave absorption. Unfortunately, both observations and modelling of total aerosol absorption, absorbing aerosol optical depths (AAOD) and single scattering albedos (SSA) (column and in-situ), as well as the vertical distribution of atmospheric absorption, still suffer from uncertainties and unknowns significant for climate applications. In this presentation, we discuss recent results on regional and global AAOD observations and retrievals from in-situ and remote sensing. We also summarize developments toward understanding the individual contributions of the three major absorbing aerosol components – commonly termed Black Carbon (BC), Brown Carbon (BrC) and mineral dust – and discuss the challenges that remain before aerosol absorption can be combined into bottom-up estimates of global AAOD with confidence. We emphasize developments in black carbon absorption alteration due to coating and ageing, brown carbon characterization, dust composition, absorbing aerosol above cloud, source modeling and size distributions, and validation of high-resolution modeling against a range of observations. Finally, we discuss some key developments that could, in our view, bring the field substantially forward.

Sogacheva, Larisa

Merging aerosol optical depth from multiple satellite missions from the last four decades

During the last four decades, numerous satellite sensors were launched and algorithms have been generated to study aerosols. However, the lifetime of the sensors is limited and datasets from different sensors and algorithms should be merged to study the long-term aerosol optical depth (AOD) trends for several decades. The exercise to study the possibility to build an AOD long-term data record has been initiated by the 5th AeroSat in Helsinki, 2017. First, AOD datasets (publicly available official products) from different satellites and algorithms were collected. Seasonal and yearly aggregated AODs were calculated from the monthly means. AOD time series were visualized for different locations: global over land, global over ocean, mainland China. For overlapping periods, the AOD difference maps were plotted, taking as a “reference” MODIS/Terra, which has better coverage over land and ocean and longer data record. AOD data from the afternoon satellite missions were also compared with MODIS/Aqua AOD. The merging technique will be discussed based on the results of the AOD inter-comparison

Schulz, Michael

Performance of 2018 Aerocom model versions against multiple observational datasets

Aerosol optical parameters are measured by ground based networks and remote sensing satellites. At the same time the latest version of AeroCom models as stored via a control run on the AeroCom database are available and give an indication of current CMIP6 models. While the latter are not yet available in full detail, the current model versions are a good proxy for the likely quality of these models. The consistency of the evaluation is tested for multiple obervational datasets. The ultimate goal is the establishment of constraints for radiative forcing estimates.

Schuster, Greg

Linking Dust Optical Properties to Source Regions Over Africa and the Middle East

The mineralogical composition of atmospheric dust varies substantially over north Africa and the Middle East. This mineralogical variability has a significant impact on the refractive indices of dust, which causes variability in the scattering and absorption optical properties. We have developed a technique for associating dust refractive indices with seven potential source areas (PSAs) located in north Africa and the Middle East. We use the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model to "tag" dust emitted from each PSA; this allows us to compute PSA mixing ratios at 19 AERONET sites every day from June 1, 2006 until Dec 31, 2016. We screen the AERONET refractive index retrievals for "pure" dust during the same time period, considering only Level 2.0 retrievals with fine volume fractions less than 0.05 and linear depolarization ratios at the 532 nm wavelength greater than 0.25. This results in 1388 retrievals, which we use with the GOCART PSA mixing ratios to implement an over-constrained Generalized Matrix Inverse to associate a refractive index with each of the seven source regions.
Our results indicate that AERONET infers the lowest real refractive indices when dust originates from northwest Africa and the Bodele Depression (n = 1.47–1.48 at 532 nm), whereas dust originating from northeast Africa has a real refractive index of 1.56. The imaginary refractive index also varies from 0.0012--0.0034 for the seven PSAs. We attribute this refractive index variability to the different dominant mineralogies of the various source regions. These mineralogical differences also impact the regional lidar ratio, which varies from 41 to 61 sr. We find that the mineralogical variability can also alter the modeled single-scatter albedo by up to ~0.015, but mineralogy has a very small impact on the modeled aerosol optical depth. We will discuss the ramifications using a single refractive index for all dust aerosols in global aerosol models.

Schutgens, Nick

Interpreting AEROCOM model errors from remote sensing observations

We evaluate AEROCOM global aerosol models against an ensemble of remote sensing datasets. These datasets come from 6 different sensors and 10 different algorithms, devised for the satellites Aqua, AURA, ENVISAT, PARASOL, noaa18, SeaStar and Terra. In addition, we evaluate both models and satellite datasets with AERONET. While most of our datasets provide only AOT (aerosol optical thickness) and often AE (Angstrom exponent), a few also provide SSA (single scattering albedo). Using the AEROCOM model ensemble, we show that strong correlations exist between e.g. assumed black carbon emissions and modelled AAOT (absorbing aerosol optical thickness), depending on the region. E.g. over the sub-tropical savannah, models show large ranges for both black carbon emissions (5.e-13 - 5.e-12 kg/m2/s) and modeleld AAOT (0.005 - 0.065). Using actual AAOT observations, we then estimate black carbon emissions at around 3.e-12 kg/m2/s. While different remote sensing observations have different errors and different spatio-temporal sampling, the estimated emissions are similar. This suggests that causally related model fields can be combined with observations to create emergent constraints on model aspects like emissions. More-over, these constraints are consistent and independent of the observational dataset used. We further explore this approach to interpreting model error by considering MAC (mass absorption cross-section) and aerosol lifetimes.

Shi, Yingxi

Quantifying the Haze Aerosol Optical Depth Over East Asia Using Modified Modis Dark Target Algorithm

Due to fast industrialization and development, China has been experiencing haze pollution episodes with both increasing frequencies and severity over the last three decades. Haze pollution severely harms the public health and disrupts the local economy. Long-range transport of pollution also impacts surrounding regions including the Korean peninsula and the Japanese archipelago. Generating accurate measurements of column integrated particulate matter from satellites is the first step to quantify, characterize and understand the impact of the haze phenomena over the entire East Asia region rather than addressing the issue locally from single point measurements. However, the complex lower boundary condition over urban areas, such as Beijing, along with the complicated aerosol composition of haze introduces difficulties for the MODIS Dark Target (DT) algorithm in its retrieval of aerosol optical depth (AOD). Filtering procedures in the DT algorithm can be altered to increase the data coverage over this region and the newly implemented urban scheme in the MODIS C6.1 DT product provides more accurate AOD retrievals over city targets. After implementing a new regional aerosol model, a more complete haze-oriented MODIS DT data set over East Asia will be generated, validated against ground-based measurements. Using this new data set, we will characterize the haze phenomena over East Asia.

Shinozuka, Yohei

Updating satellite-based estimates of aerosol-cloud interactions with refined approximation of cloud condensation nuclei

Some atmospheric particles are capable of initiating droplet formation at a supersaturation. Aerosol-cloud interactions (ACI) mediated by these cloud condensation nuclei (CCN) remain poorly quantified. Satellite observations yield estimates of ACI in ways that complement model-based studies. Updating the estimates with extended satellite records would improve the statistics and illuminate multi-decadal trends. Satellite-based ACI studies simplistically substitute aerosol optical depth (AOD) times its wavelength dependence for CCN. Emerging model and satellite capabilities promise refined CCN approximation, warranting evaluation with direct measurements. We refine CCN approximation and update satellite-based ACI estimates. To refine CCN approximation, we obtain light extinction and its wavelength dependence from MERRA-2 reanalysis, compute CCN proxies and analyze errors using suborbital measurements. Specifically, the boundary-layer extinction determined by MERRA-2 reanalysis are used to calculate the so-called aerosol index and the recently developed CCN indices, each on a column-integral basis and on an altitude-resolved basis, the latter more relevant to the boundary-layer CCN. These CCN approximations are evaluated with the direct measurements in DOE ARM facilities (e.g., Southern Great Plains and Azores) and NASA research flights (e.g., ARCTAS, DISCOVER-AQ and ORACLES). To update satellite-based ACI estimates, we match decades-long cloud products to the approximated CCN, run regression and investigate the impact of environmental and technical factors.

Specifically, the MODIS derived boundary-layer cloud droplet number concentration since 2003 are co-located with the CCN approximations. Linear regression on log-log scales between each cloud property-CCN pair is studied. Our preliminary analysis suggests that, because Aerosol Index varies more than CCN, the regression slope, which past studies identified with the strength of ACI, may be underestimated. We plan to extend the analysis to other data source (e.g., Deep Blue, PARASOL GRASP) and cloud properties (e.g., optical thickness, effective radii); estimate the humidification effect from the MERRA-2 aerosol species and relative humidity; deduce the uncertainty for the global CCN approximations; and study the regional, seasonal and multi-year trends of the regression results. The analysis is expected to help make recommendations on future efforts and discuss implications for radiative forcing calculations.

Smith, Steve

Emissions Data for Earth System and Aerosol Models: A Multi-Model Sensitivity Evaluation

Modeling historical and future atmospheric conditions depends on well-characterized estimates of aerosol, precursor and reactive gas emissions. Many aspects of emissions data are uncertain including not only emissions magnitude at the country-level, but also emission location, effective injection height, and seasonality. The sensitivity of models to these unknowns has not been systematically evaluated, meaning that we do not know what portions of inventories are most important to better quantify. We have proposed to use a set of multi-model sensitivity tests to determine which aspects of aerosol-related emissions impact model results. This talk will give an overview of the project to invite community participation. Phase 1 of the project is suitable for participation by CTMs, and will explore a range of sensitivities using modest computational resources. Phase 2 will use coupled models to explore a selected sub-set of sensitivities. Perturbed emissions data will be produced using the Community Emissions Data System (CEDS), in the same format as was released for use in CMIP6, reducing set-up burdens on modeling groups.

Impact of SO2 Injection Height On Satellite Inferences of Emission Trends

Satellite data has the potential for providing timely information on air pollutant emission fluxes for molecular species that can be detected from space. Using satellite data to infer emission trends, however, assumes that underlying conditions not directly observed are constant over time. One important uncertainty in current emission datasets is the effective emission height, which has been shown to have a significant impact on the vertical distribution of sulfur dioxide (SO_2) concentrations. We demonstrate here, using China SO_2 emissions as an example, the extent to which the changing sectoral composition of China SO_2 emissions over the last two decades might influence inferences about emission trends using satellite data time series.

Su, Tianning

Methods to Retrieve PBLH from Ground-based and Space-borne Lidars and Application to Air Pollution Studies

Planetary boundary layer height (PBLH) is a key factor in the vertical mixing and dilution of near-surface pollutants, and is closely associated with air pollution episodes. Ground-based lidars measure the aerosol vertical distribution with high resolution, and space-borne lidars provide spatially extensive vertical coverage, offering a potential for tracking PBLH. In our study, we explore and develop different techniques for retrieving PBLH from space-borne lidar (CALIPSO) and ground-based lidar, and validate them against those obtained from radiosonde data, which we consider ground truth. For CALIPSO, two techniques are examined: MSD (maximum standard deviation) and WCT (wavelet covariance transform), and their hybrid, which shows better performance. The uncertainties and causes are investigated; their worst performance occurs at low aerosol loading and elevated aerosol layers. For ground-based lidar, the performance is assessed under different thermodynamic stability using 8-years of micropulse lidar and radiosonde measurements at the ARM Southern Great Plains site. A new method is proposed to improve the accuracy of PBLH estimation, especially its diurnal variation, by fusing lidar data with radiosonde data. By utilizing CALIPSO and ground-based lidars, we investigate the relationship between PBLH and surface PM (particulate matter) over China, its spatial pattern and influential factors (Su et al., 2018). A generally negative correlation is observed between PM and the PBLH, as expected, albeit varying greatly in magnitude and significance with location and season. Nonlinear responses of PM to PBLH evolution are found, especially over the North China Plain (NCP). Strongest PBLH-PM interaction is found when the PBLH is shallow and PM concentration is high, which typically corresponds to the wintertime cases. Correlations are much weaker over highland than plain regions, which may be associated with lighter pollution loading and more dominant role of mountain breezes. The influence of horizontal transport on surface PM is considered as well, manifested as a negative correlation between surface PM and wind speed over the whole nation. Strong wind with clean upwind sources plays a dominant role in removing pollutants, and leads to weak PBLH-PM correlation. A ventilation rate is introduced to jointly consider horizontal and vertical dispersion, which has the largest impact on surface pollutant accumulation over NCP.

Su, Wenying

Evaluating the AeroCom Phase III top-of-atmosphere fluxes using the CERES product

The Clouds and the Earth's Radiant Energy System (CERES) project produces a long-term global climate data record (CDR) that can be used to detect decadal changes in the Earth's radiation budget (ERB) from the surface to the top-of-atmosphere (TOA). Imager-based cloud and aerosol retrievals are included in the CERES flux product. This dataset has played a crucial role in improving our understanding of the variability in Earth's radiation budget, the role of clouds and aerosols in altering the radiation budget, and the evaluation of climate models. In this study we compare the TOA clear-sky fluxes from Aerocom phase III output with those from the CERES products. Two CERES TOA clear-sky flux products are used: one is from the CERES Energy Balanced and Filled (EBAF) product and the other is from the CERES Synoptic (SYN1deg) product. The CERES EBAF product provides a gap-free monthly mean clear-sky flux map by inferring clear-sky fluxes from both CERES and MODIS measurements. In EBAF, the CERES-derived clear-sky TOA fluxes are supplemented by TOA fluxes inferred from MODIS radiances using predetermined narrowband-to-broadband regressions. CERES SYN1deg product provides calculated clear-sky fluxes using aerosol optical depths (AOD) retrieved from MODIS and/or from the Model for Atmospheric Transport and Chemistry (MATCH) aerosol assimilation. Initial comparison indicates that the AeroCom models tend to underestimate the TOA clear-sky reflected SW fluxes over ocean and overestimate the TOA clear-sky reflected SW fluxes over snow/ice. Additionally, the CERES/AeroCom differences are generally greater over land than those over ocean and the magnitude of the differences shows seasonal and regional dependency.

Taha, Ghassan

OMPS LP observations of the Asian tropopause aerosol layer

The presence of an enhanced aerosol layer within the Asian monsoon anticyclon was first identified using CALIPSO observation (Vernier et al., 2011), and later confirmed by SAGE II observations (Thomason and Vernier, 2013). The Asian Tropopause Aerosol Layer (ATAL) is primarily observed in June / July / August, and extend between 10-30o N and 40-120o E, between 14 and 18 km. In this study, we will analyze daily measurements of OMPS LP aerosol extinction coefficient profiles at 675nm to identify the extent and seasonality of the ATAL layer during the period of 2012-2018. Initial results shows enhancement of the background aerosol over the ATAL region during the associated seasons. Although OMPS LP algorithm screens for cloud interference, our analysis indicates more rigorous cloud screening is needed to reduce the influence of clouds interference on the measured aerosol extinction in the upper troposphere/Lower stratosphere (UT/LS) region. OMPS LP daily aerosol measurements over the ATAL region can provide improved temporal and spatial variability of the UT aerosols needed to evaluate and improve global aerosol models.

Tegen, Ina

Modelling absorbing aerosols and their effects with ECHAM6.3-HAM2.3

We present direct and semi-direct radiative forcing results with the ECAM-HAM model (release version ECHAM6.3-HAM-2.3) considering the effects of black carbon and mineral dust aerosols. Semi-direct effects are approximated as residual between the total direct radiative effect and the instantaneous direct radiative effect of the simulated absorbing aerosol species, not distinguishing between aerosols from natural and anthropogenic sources. Results for global average are highly uncertain due to high model variability, but consistent with previous estimates. The presence of mineral dust aerosol above dark surfaces and below a layer containing black carbon aerosol may enhance the reflectivity and act to enhance the positive radiative effect of black carbon aerosol. In addition, the sensitivity of the model results for black carbon aerosol to different emission scenarios is evaluated.

Torres, Omar

Stratospheric Injection of Massive Smoke Plume from Canadian Boreal Fires in 2017 as seen by DSCOVR-EPIC, CALIOP and OMPS-LP Observations

Unprecedented amounts of tropospheric carbonaceous aerosols generated by wildfires in British Columbia (BC) on August and September 2017 were injected into the stratosphere on at least three different occasions. This extraordinary event was observed from space by both active and passive, profiling and mapping sensors. The Earth Polychromatic Imaging Camera (EPIC) onboard the Deep Space Climate Observatory (DSCOVR) at the L-1 point observed the spatial and temporal evolution of the aerosol plume for about six weeks since the onset of the wildfires in early August.CALIOP profiles of attenuated backscatter were used to constrain the aerosol layer height as the plume travelled above tropospheric water clouds in some instances and in completely clear skies on others. Total column AOD as large as 6 were retrieved by EPIC and confirmed by AERONET observations, The temporal extent of the BC plume stratospheric aerosol perturbation lasted about 10 months, and its effect in terms of increased aerosol extinction in the stratosphere was comparable to that of a moderate volcanic eruption.

Vandenbussche, Sophie

MAPIR version 4 dust 3D retrievals from IASI: improved algorithm, validation and applications

The Royal Belgian Institute for Space Aeronomy (BIRA-IASB) has developed a retrieval algorithm providing mineral dust aerosols vertical profiles from thermal infrared radiances measured by the IASI instrument onboard the Metop satellite series. This strategy is called Mineral Aerosol Profiling from Infrared Radiances (MAPIR). The previous version 3 has been used under ESA's Climate Change Initiative aerosols project to produce 9 years of dust 3D distributions. The validation has shown an AOD overestimation but a good mean aerosol altitude. That version 3 has shown additional significant issues over low emissivity areas, linked to the radiative transfer code used (lidort v2.7). To solve it, we have developed an entirely new version of MAPIR, using another radiative transfer (RTTOV). This also needed a new interface, and we took the opportunity to develop a new more flexible retrieval algorithm. As retrieval strategy, MAPIR v4 uses the optimal estimation with the Levenberg-Marquardt formulation. MAPIR v4.1 is currently used for a reprocessing of a full IASI time series of 4D dust aerosol distributions that will become available through the Copernicus Climate Change Services.

Von Salzen, Knut

Validation of PAM on Regional and Global Scales

The latest generation of the Canadian Global Atmospheric Climate Model (CanAM5) is currently being finalized and evaluated. In CanAM5, the Piecewise Lognormal-Approximation Aerosol Model (PAM) is available for simulations of aerosol microphysical processes and interactions of aerosols with radiation and clouds. Simulations of global aerosols and climate with CanAM5/PAM are validated using a range of different observational data sets, including in-situ measurements near the surface and satellite data retrieval products. Aerosol properties relevant to aerosol indirect effects on clouds are addressed, including concentrations of Cloud Condensation Nuclei (CCN) and cloud droplet number. Model results for aerosol chemical composition and particulate matter (PM) concentrations are also analyzed. These comparisons provide strong constraints with regard to applications of the model system for simulations of climate and air quality.

Watson-Parris, Duncan

The limits of CALIOP for constraining modelled free-tropospheric aerosol

The space-borne Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) instrument provides valuable information on the vertical distribution of global cloud and aerosol, and the aerosol profile data is often used to evaluate vertical aerosol distributions in General Circulation Models (GCMs), partly due to the absence of any other global-scale constraints. Here we show, however, that the detection limit of CALIOP means it does not detect background aerosol, leading to substantially skewed statistics that moreover differ significantly by product. Using the global aerosol climate model ECHAM-HAM, we estimate that CALIOP nighttime (daytime) retrievals miss 42% (44%) of aerosol mass in the atmosphere. In the CALIOP Level 2 product this missing low-backscatter aerosol results in the retrieved aerosol distribution significantly over-representing aerosol backscatter and extinction in the mid- and upper-troposphere if not accounted for.

… for **Lee, Lindsay**

The AeroCom Multi-Model Perturbed Parameter Ensemble (MMPPE)

This is an update on the BC and Cloud perturbation experiments. (1) The BC experiment is perturbing emissions, imaginary part of the refractive index and wet deposition to explore the parametric uncertainty and intermodal spread in AAOD due to BC. (2) The Cloud experiment is exploring uncertainty in aerosol activation and precipitation in a similar manner.

The AeroCom aircraft comparison experiment

Recent dedicated aircraft measurement campaigns and data collection efforts have delivered a large amount of in-situ aerosol measurements of great value to AeroCom modelers. The Global Aerosol Synthesis and Science Project (GASSP) dataset[1] brings 1000s of separate aircraft measurement flights across 10s of campaigns into a single consistent database. Combining this with data from recent campaigns such as CLARIFY, ORACLES[2], AToM and ACE-ENA provides a unique opportunity to evaluate AeroCom model aerosol distributions across a wide range of regions and meteorological conditions. Each campaign includes different measurements of aerosol properties such as size distributions and speciation, and each focuses on different regions or phenomena; however, they all provide valuable model constraints and all require similar sampling considerations. Building on the Phase II experiments this experiment requires the interpolation of consolidated flight track points from high-temporal resolution model output to minimize the large sampling biases that would otherwise be present. We present preliminary results investigating the aerosol size distribution across AeroCom models as compared to the observations and interpreted against the low-bias in large upper tropospheric aerosol uncovered in a detailed evaluation of ECHAM-HAM. A number of further analyses made possible by this framework, such as investigations into biomass burning aerosol ageing and removal and ACI case-studies, will also be discussed.

Williamson, Christina

Global Scale Measurements of Aerosol Properties in the Remote Atmosphere from the NASA Atmospheric Tomography Mission
(key-note presentation)

We recently flew a substantial aerosol payload on the NASA Atmospheric Tomography Mission (ATom): four sets of research flights over the remote Pacific and Atlantic oceans. The flights were conducted once in each of the four seasons, with near pole-to-pole coverage, and constant profiling between 0.2 and 12 km altitude. We measured aerosol size-distributions from 2.7 nm to 930 μm, cloud properties, size resolved single particle composition from 0.2 to 3μm, bulk composition of non-refractory aerosol and black carbon concentration, mass and coating-state. Aerosol extinction and absorption are calculated from the size distributions and composition. Here we summarize the data products available from this mission, and highlight seasonal snapshots and select features observed in the remote atmosphere. These include patterns of free tropospheric new particle formation and aerosol acidity, the global distribution of mineral dust, sea-salt, organic aerosol and black carbon, and analysis of aerosol transport, removal and processing.

Winker, Dave

Intercomparison of global aerosol direct radiative effect estimates based on CALIOP

A number of studies have estimated the global clear-sky and all-sky aerosol direct radiative effect using CALIOP aerosol data. There are significant differences in these estimates, however, even though they are mostly based on the same datasets. In this presentation we examine reasons for these differences and the extent to which they can be reconciled. Then we examine biases between estimates of the clear-sky effect based on CALIOP and based on MODIS, and attempt to place bounds on the uncertainties.

Wu, Chenglai

Impacts of climate change and land use change on dust emission in East Asia

Dust aerosol plays an important role in the Earth System. As a natural aerosol, dust aerosol is often calculated interactively in global climate models and temporal variations of dust emission in the past century are far less constrained compared to those of anthropogenic aerosol emissions. In this study, we use both observations and Community Earth System Model (CESM) simulations to quantify the impacts of climate change and land use change on spatio-temporal evolution of dust emission in East Asia. First, based on dust event record from World Meteorological Organization (WMO) weather stations, we show that dust event frequency decreased significantly during 1961-2005 in northern China. The dust event can be largely ascribed to the decline of surface wind speed and to a less extent to the increase of precipitation and soil moisture. Land use also showed substantial changes during 1961-2005, which may also contribute to the change of dust event frequency, but the contribution of land use change is hard to distinguish from the contributions of surface wind speed and precipitation change. Therefore, in the second part of this study, we will quantify the impacts of these factors to dust emission variations through CESM simulations with constrained meteorology (by using nudging technique). Through the comparison of two simulations with constant land use and with historical land use, respectively, the contribution from land use change will be derived. We will also discuss the uncertainties of results, which mainly lay in the dust emission scheme, soil moisture discrepancy, and land use data.

Yang, Dongdong

The variation of simulated concentration in anthropogenic PM2.5 and its effects on climate

We simulate the temporal and spatial variations of the concentration in anthropogenic PM2.5 that includes sulfate (SF), black carbon (BC), and organic carbon (OC) and its effects on climate over the globe and China from 1850 to 2010 using an aerosol-climate coupled model BCC_AGCM2.0.1_CUACE/Aero. The results show that the column burden of anthropogenic PM2.5 in the atmosphere increases in most areas since 1850, with a very high increment mostly occurring over East China, South Asia, southeast North America, and southeast Europe. The global annual mean column burden of anthropogenic PM2.5 is increased by 2.9 mg m-2. The variations of SF, BC, and OC contribute to 83%, 4%, and 13% of the total increase, respectively. The global annual mean effective radiative forcing (ERF) at the top of the atmosphere due to anthropogenic PM2.5 is -2.1 W m-2. The increase in total anthropogenic PM2.5 since 1850 leads to decreases in global annual mean surface net radiative flux of 5.5 W m-2 and surface temperature of 2.3 K. There is a distinct cooling over most lands, as well as oceans in the middle and high latitudes of the Northern Hemisphere (NH). The Hadley Circulation in the NH is enhanced and shifted southwards, and the Intertropical Convergence Zone (ITCZ) is moved southwards thereupon due to the increase in total anthropogenic PM2.5. Both the global annual mean precipitation and evaporation are decreased by about 0.19 mm day-1 and the surface relative humidity is increased by about 0.22%. Besides, the temperature over most areas of China also declines because of an increase in anthropogenic PM2.5. The annual mean surface temperature and precipitation over China are decreased by 3.3 K and 0.52 mm day-1, respectively, which are significantly larger than those over the globe. The change in atmospheric circulation suppresses the rainfall over the East Asian monsoon region in winter, but is beneficial to the rainfall over South China in summer.

Xie, Bing

Effective radiative forcing and climate response to short-lived climate pollutants under different scenarios

We used an online aerosol–climate model (BCC_AGCM2.0_CUACE/Aero) to simulate effective radiative forcing (ERF) and climate response to changes in the concentrations of short-lived climatic pollutants (SLCPs), including methane, tropospheric ozone, and black carbon, for the period 2010–2050 under Representative Concentration Pathway (RCP) scenarios (RCPs) 8.5, 4.5, and 2.6. Under these three scenarios, the global annual mean ERFs were 0.1 W m–2, –0.3 W m–2, and –0.5 W m–2, respectively. Under RCP 8.5, the change in SLCPs caused significant increases in surface air temperature (SAT) in mid- and high latitudes of the Northern Hemisphere (NH) and significant decreases in precipitation in the Indian Peninsula and equatorial Pacific. Global mean SAT and precipitation increased by 0.13 K and 0.02 mm day–1, respectively. The reduction in SLCPs from 2010 to 2050 under RCPs 4.5 and 2.6 led to significant decreases in SAT at high latitudes in the NH. Precipitation increased slightly in most continental regions, and the Intertropical Convergence Zone moved southward under both of these mitigation scenarios. Global mean SAT decreased by 0.20 K and 0.44 K, and global averaged precipitation decreased by 0.02 and 0.03 mm day–1 under RCPs 4.5 and 2.6, respectively.

Xue, Yong

Evaluation of the AVHRR DeepBlue aerosol optical depth dataset over mainland China

Advanced Very High Resolution Radiometer (AVHRR) on-board NOAA series satellites have been used to observe the Earth's surface and clouds for almost 40 years. Limited by bands and problematic instrument calibration, aerosol studies using AVHRR data have focused on retrieving data over the ocean. However, continuous developments have made it possible to retrieve aerosol over land as well. The newly implanted AVHRR Deep Blue (DB) technique has been applied to process global aerosol datasets over both land and the ocean during 1989-1990, 1995-1999 and 2006-2011. This paper aims to evaluate, in detail, the performance of the AVHRR DB aerosol optical depth (AOD) dataset over mainland China by comparison with both ground-based data and satellite aerosol products. The ground-based validation results show that DB AOD is close to ground-based AOD when AOD is moderate during winter, while DB underestimates AOD when AOD increases over 1.0 during summer over vegetated surfaces. AVHRR DB underestimates dry, urban and transitional surfaces in Western China due to the high uncertainty in low retrievals over bright surfaces. Cross-comparison with the Moderate-resolution imaging spectrometer (MODIS) DB aerosol dataset shows that the disadvantages of the single longer visible bands are greatly increased over bright surfaces. Together with problematic instrument calibration, the differences between the two datasets over most of mainland China are significant. Meanwhile, the differences show strong seasonal variation characteristics.

Synergetic retrieval of aerosol optical depth over land from geostationary satellite GEOS-R Data

Aerosol optical depth (AOD) is an important parameter in many fields such as climate change, quantitative remote sensing and atmospheric environmental monitoring. However, aerosol distribution has a strong spatio-temporal difference due to the short life cycle of aerosols and the spatial variability of aerosol emissions. Therefore, it is very important to rapidly monitor the aerosol over a wide range. Retrieval of AOD using polar orbit satellite data is the current mainstream approach, but the time resolution of polar-orbiting satellites is very low, and it is impossible to truly realize the effective monitoring of the large range of AOD. Compared with polar-orbiting satellites, geostationary satellites can effectively solve this problem. The data used in this study are obtained by the geostationary satellite GEOS-R (75° West). The instrument Advanced Baseline Imager (ABI) of GEOS-R generates images of the Earth in 16 different spectral bands (VIS 0.47, VIS 0.64, VIS 0.86, NIR 1.37, IR 1.6, IR 6.2, IR 2.2, IR 3.9, etc.) with a repeat cycle of 15minutes. In this study, we use two visible bands (VIS0.47 and VIS0.64) and one near-infrared band (NIR 2.2) for AOD retrieval. At present, researchers have developed a variety of AOD retrieval algorithms for single satellite such as MODIS, but most algorithms can only generate daily AOD data sets (which cannot effectively reflect the real-time changes of AOD), or Multiple consecutive cloudless observations are required (reducing the coverage of AOD products). In order to solve the shortcomings of existing algorithms, we proposed a synergetic algorithm that can retrieve AOD with a time resolution of 15 minutes using GEOS-R data, which can accurately reflect the real-time changes of AOD. The synergetic algorithm can retrieve the AOD using a cloudless observation data (There is no need for continuous cloudless observation). Thus the algorithm proposed in this study will be able to further expand the coverage of AOD products.

Yorks, John

The Cloud-Aerosol Transport System: 33 Months of Aerosol Vertical Profiles from the International Space Station

The Cloud-Aerosol Transport System (CATS) is an elastic backscatter lidar that operated for 33 months (Feb. 2015 to Oct. 2017) on-orbit from the International Space Station (ISS), firing over 200 billion laser pulses. The CATS instrument was designed to demonstrate new in-space technologies for future Earth Science missions while also providing vertical profiles of clouds and aerosols. CATS operated the first 6 weeks in a mode that provided dual wavelength backscatter and depolarization measurements (532 and 1064 nm) using 2 beams. After the first laser failed, the last 31 months of operation were limited to single wavelength backscatter and depolarization measurements using one beam. A unique feature of CATS is the observing profile due to the ISS orbit, which is very different from the sun-synchronous orbits of CALIPSO and other NASA A-Train sensors. The ISS orbit provides comprehensive coverage of the tropics and mid-latitudes (over the primary aerosol transport tracks) with nearly a three-day repeat cycle that passes over the same locations at different local times each overpass. CATS has shown that A-Train sensors (passing over the same location at the same local time every overpass) are only capturing a “snapshot” of the diurnal cycle. New CATS data products, the most accurate yet, will be released in late 2018 and are very similar to CALIPSO data products. However, data users should be aware of several differences between the two instruments. (1) CATS and CALIOP use different techniques (laser repetition rates, laser energy, detection) that have implications for signal-to-noise ratio and sampling complex scenes. (2) CATS measurements are primarily limited to robust 1064 nm backscatter and depolarization ratio. CALIOP measures backscatter at 1064 and 532 nm, as well as depolarization ratio at 532 nm. (3) These fundamental differences result in algorithm differences between the two instruments that can impact specific applications. This presentation will provide an overview of the CATS project, outline the differences compared to CALIPSO, and discuss the utility of CATS data products for applications such as aerosol diurnal variability, plume transport, near-IR aerosol optical properties, and above cloud aerosol (ACA) detection.

Yu, Fangbin

Spatial variations of AOD-CCN correlations and implications for aerosol indirect radiative forcing

Aerosol particle concentrations due to anthropogenic emissions influence climate change indirectly by acting as cloud condensation nuclei (CCN), altering cloud properties, albedo, and precipitation. Aerosol albedo effect or first indirect radiative forcing (FIRF) remains to be one of the primary sources of uncertainty in assessing climate change. Observation based estimates of FIRF have been made possible through the advancement of remote sensing from space. Compared to model-based FIRF, the observation-based values are similar in magnitude over oceans but are generally much lower (less negative) in major industrial regions. A recent study shows an opposite aerosol-cloud correlation between land and ocean, namely cloud droplet effective radius (CER) is positively correlated with aerosol index (AI) over three major industrial regions, but negatively correlated over their adjacent oceans. The positive CER-AI slope, also known as anti-Twomey effect, may explain the weaker observation-based FIRF. While the anti-Twomey effect has been reported in a number of previous publications, the physical reasons behind this remain unclear. All previous studies on aerosol-cloud interactions through analysis of the connection between CER and AI (or aerosol optical depth (AOD)) largely rely on the assumption that AI or AOD can be used as a proxy for CCN. However, AI or AOD is a column integrated parameter while clouds are mainly influence by aerosols surrounding the clouds. Here we employ GEOS-Chem-APM, a global chemical transport model with size-resolved particle microphysics, to investigate the relationship between column-integrated AOD and CCN/CDN in different altitudes under different environments (locations, seasons). The GEOS-CHem-APM simulated AOD has been validated against AEORNET and satellite observations, while the particle mass and number concentrations are shown to agree well with surface measurements. Our results indicate that AOD or AI is not well representative of the CCN over some industrial regions, but they correlate well with CCN over adjacent oceans in the layers where warm clouds typically form. The correlations also vary with altitudes. The physical reasons behind the variations in the correlations of AOD with CCN/CDN at different locations/altitudes will be presented and implications to the aerosol indirect radiative forcing will be discussed.

Yu, Hongbin

African Dust and Trans-Atlantic Transport and Deposition: Satellite Observations and GEOS-5 Modeling

This presentation provides updates on a study of African dust and trans-Atlantic transport and deposition using a suite of satellite measurements and the GEOS-5 model. One of major updates is a derivation of the 10-year record of seasonal dust deposition into ocean and loss frequency at a spatial resolution of 5degx2deg through integrating CALIOP, MODIS, MISR, and IASI aerosol retrievals. Another major update is the use of recently released EPIC/DSCOVR MAIAC aerosol retrievals to study the sub-daily evolution of African dust in source regions and along the trans-Atlantic transport route at a temporal resolution of 1-2 hours. The GEOS-5 model simulations are compared with the EPIC MAIAC observations.

Yu, Yan

Is Bodélé depression the dominant source of North African dust transported to the Americas? Insights from MISR observations and trajectory modeling

Dust from North Africa has been reported to affect the air quality in Caribbean Basin (Prospero et al. 1972, 1981, 2013, 2014) and southeast United State (Prospero 1999), as well contributing nutrients to fertilize the Amazon forest (Ben-Ami et al. 2010). Past studies debated about the dust sources in North Africa that are responsible for the trans-Atlantic transport of dust, namely how often the dust found at the Americas comes from the Bodélé depression - world's most important dust source (Koren et al. 2006), versus other African dust sources, such as the West African deserts (Ridley et al. 2012). In the current study, the climatology of dust activation and transport from the Bodélé depression and West African desert are investigated using stereo observations from the Multiangle Imaging SpectroRadiometer (MISR) instrument combined with observation-initiated trajectory modeling. In particular, wet and dry deposition are considered in the trajectory analysis. We found that neither the Bodélé depression or West African desert significantly contributes to Amazon dust in the boreal winter growing season. In boreal summer, the Bodélé depression and West African desert contribute similar amount of dust to the Caribbean islands and southeastern US, both of which has been largely overestimated by previous trajectory analysis due to absence of dry or wet deposition in the model. For dust particles emitted from both dust sources, wet deposition overwhelms dry deposition during the trans-Atlantic transport. The wet deposition, probably driven by the substantial rainfall associated with ITCZ, largely reduces the amount of dust transport to south America.

Yuan, Tianle

The impact of the Hawaiian Volcano on aerosols, clouds, and energy budget

Using observations, we show the impact of the Hawaiian Volcano on the distribution and variability of aerosols observed from multiple sources. Due to the emission strength changes, aerosol loading in downwind areas has substantially changed at many time scales. The influence of meteorology is also visible. Clouds and precipitation is strongly affected for regions relatively close to the source. Further downwind the impact diminishes quickly. Clouds are shown to be higher and produce less precipitation within a few hundred kilometers of the volcano. Accordingly, energy fluxes change substantially due to aerosol direct and indirect effects. The variability and relatively complete coverage of the aerosol-cloud-radiation from observations offer excellent constraints for models.

Zhang, Hai

An Evaluation of VIIRS Dust Detection Algorithms over Land

This presentation compares three dust detection algorithms over land that were developed to test on Suomi National Polar Orbiting Partnership Visible Infrared Imaging Radiometer Suite (SNPP VIIRS) and to implement operationally for near real time processing. The three algorithm approaches use different spectral bands, namely deep blue bands, IR-visible bands, and IR bands and are applied for dust observed over dark as well as bright surfaces. The evaluations are performed both using case studies and AERONET matchup data over western CONUS-Mexico region and North Africa-Arabian Peninsula region. The deep blue based algorithm is found to have the most false detections and its detection performance depends on the Sun-Satellite geometries. Simulation analysis shows that there are three causes of this problem: surface reflectance, air mass factors, and phase functions in different geometries. The algorithm based on IR-visible bands has much less false detection than deep blue bands based algorithm and has better true positive detection than the IR based algorithm. The results suggest that the IR-visible algorithm is most suitable for the dust detection of the three algorithm with a small modification.

Zhang, Zhibo

Net radiative effects of dust in the tropical North Atlantic based on integrated satellite observations and in situ measurements

In this study, we integrate the recent in situ measurements with satellite retrievals of dust physical and radiative properties to quantify the dust direct radiative effects on the shortwave (SW) and longwave (LW) radiation (denoted as DRESW and DRELW, respectively) in the tropical North Atlantic during summer months from 2007 to 2010. Through linear regression of CERES measured top-of-atmosphere (TOA) flux versus satellite aerosol optical depth (AOD) retrievals, we estimate the instantaneous DRESW efficiency at the TOA to be –49.7±7.1 W/m2/AOD and –36.5±4.8 W/m2/AOD based on AOD from MODIS and CALIOP, respectively. We then perform various sensitivity studies based on recent measurements of dust particle size distribution (PSD), refractive index, and particle shape distribution to determine how the dust microphysical and optical properties affect DRE estimates and its agreement with abovementioned satellite-derived DREs. Our analysis shows that a good agreement with the observation-based estimates of instantaneous DRESW and DRELW can be achieved through a combination of recently observed PSD with substantial presence of coarse particles, a less absorptive SW refractive index, and spheroid shapes. Based on this optimal combination of dust physical properties we further estimate the diurnal mean dust DRESW in the region of –10 W/m2 at TOA and –26 W/m2 at surface, respectively, of which ~30% is canceled out by the positive DRELW. This yields a net DRE of about –6.9 W/m2 and –18.3 W/m2 at TOA and surface, respectively. Our study suggests that the LW flux contains useful information of dust particle size, which could be used together with SW observation to achieve more holistic understanding of the dust radiative effect.

Zhao, Xuepeng

Studying the Sensitive Regimes and Active Regions of Aerosol Indirect Effect for the Clouds over the Global Oceans by Using Long-Term Satellite Observations

Cloud microphysical structures and properties provide a critical link between the energy and hydrological cycles of Earth's climate system. Atmospheric aerosol is the major source of cloud condensation nuclei (CNN) and ice nuclei (IN) that are critical for the formation of cloud microphysical structures and properties. Aerosol changes due to anthropogenic emissions will result in the modification of CCN/IN and cloud microphysical properties and eventually cause the changes of Earth's climate. In this study, we will investigate the effect of aerosol on the cloud microphysical properties of marine water and ice clouds by using more than 30-years climate data records (CDRs) of aerosols and clouds derived from NOAA operational AVHRR satellite observations. The objective is to identity the aerosol indirect effect (AIE) signatures contained in the long-term satellite observation. Our study focuses on identifying the regimes and regions that the positive and negative AIE may clearly manifest in a sense of long-term average over the global oceans.

Zheng, Youtong

Towards satellite inference of the decoupling degree and cloud-base updrafts of marine stratocumulus and application to aerosol-cloud interactions

To what extent surface-originated aerosols impact boundary layer warm clouds is influenced by the degree of cloud-surface coupling and the cloud-base updrafts. Neither of these two variables, however, is retrievable from satellite. This study concerns itself with developing satellite-based methods of inferring the decoupling degree and the cloud-base updrafts for marine stratocumulus (Sc) over subtropical oceans. The estimation concept of the coupling state is that decoupled Sc clouds under cold-advection conditions, which are typical in subtropical oceans, are fed by spreading of the tops of cumulus clouds that are coupled. The cumulus clouds constitute a much larger liquid water path (LWP) over small areas which is identified by a positive skewness of the LWP, a quantity measurable from high-resolution satellite data. We estimate the cloud-base updrafts by quantifying the cloud-top radiative cooling rate that, in combination with the decoupling degree, determines the turbulence level at the cloud bases. These concepts and the satellite-based estimations are supported by ship measurements over the northeast Pacific. Preliminary results of applying these new techniques to studying the aerosol-cloud interactions will be shown.

Zhou, Yaping

Implementing Non-Spherical Dust Aerosol Model in the MODIS Dark Target Aerosol Retrieval Algorithm Over Ocean

The Dark-target (DT) aerosol retrieval is an operational algorithm of Moderate-resolution Imaging Spectrometer (MODIS) on Terra and Aqua satellites that retrieves spectral aerosol optical depth (AOD) over land and ocean since 2000 and 2002, respectively. Recently, DT has been implemented to Visible Infrared Imaging Radiometer Suite (VIIRS) aboard Suomi-NPP. Over the ocean, the DT algorithm is known to provide biased retrievals of AOD, Angstrom Exponent (AE) and fine mode fraction (FMF), especially in scenes known to be dust of African or Asian origin. These biases are scattering angle dependent and suggest errors in the phase function of spherical dust models used.

In this work, we experimented on dust AOD retrieval with a two-step strategy: first, dusty pixels are identified using a combined near-UV (Deep blue), visible, and thermal infrared (TIR) wavelength spectral tests; second, non-spherical dust models and lookup tables (LUT) are created for identified dusty pixels in the retrieval process. Many sensitivity tests are conducted to search for the proper dust models (size distribution, shape and refractive indices) that can represent space-based spectral and angular characteristics of dust aerosol. In particular, we compared ensemble dust optical properties from different models (GRASP and its earlier versions), databases (Texas A & M), shapes (sphere, spheroid and ellipsoid) and volume vs surface area equivalency assumptions. Initial results on sample granules and collocated AERONET pixels indicate that retrieval with non-spherical dust models can eliminate some scattering angle dependent bias in retrieved AOD and AE.