ABSTRACTS

of presentations during the

19th AeroCom

and the

8th AeroSAT

workshops

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in alphabetical order by presenter

ORAL title
POSTER title

An, Qi

The Development of an Atmospheric Aerosol/Chemistry- Climate Model, BCC_AGCM_CUACE2.0, and Simulated Effective Radiative Forcing of Nitrate Aerosols

This study developed a next-generation atmospheric aerosol/chemistry-climate model, the BCC_AGCM_CUACE2.0. Then, the performance of the model for nitrate was evaluated, and the nitrate direct radiative forcing (DRF) and effective radiative forcing (ERF) due to aerosol-radiation interactions were simulated for the present day (2010), near-term future (2030), and middle-term future (2050) under the Representative Concentration Pathway 4.5, 6.0, and 8.5 scenarios relative to the preindustrial era (1850). The model reproduced the distributions and seasonal changes in nitrate loading well, and simulated surface concentrations matched observations in Europe, North America, and China. Current global mean annual loading of nitrates was predicted to increase by 1.50 mg m−2 relative to 1850, with the largest increases occurring in East Asia (9.44 mg m−2), Europe (4.36 mg m−2
), and South Asia (3.09 mg m−2). The current global mean annual ERF of nitrates was −0.28 W m−2 relative to 1850. Due to global reductions in pollutant emissions, the nitrate ERF values were predicted to decrease to −0.17, −0.20, and −0.24 W m−2 in 2030 and −0.07, −0.18, and −0.19 W m−2 in 2050 for Representative Concentration Pathway 4.5, 6.0, and 8.5 relative to 1850, respectively. Although global mean nitrate values showed a declining trend, future nitrate loading remained high in East Asia and South Asia.

Andrews, Betsy

Aerocom Phase III evaluation with optical property observations

A suite of aerosol optical property observations (AOD, AE and surface in-situ scattering and absorption coefficients) from a variety of platforms (four satellite AOD products, AERONET, and surface in-situ) were used to evaluate 14 AeroCom Phase III model simulations from the CTRL exercise. We found that the model simulations tend to underestimate observed AOD by 16-37% (depending on platform). AERONET and the AATSR-SU satellite retrievals also provide information about fine and coarse mode AOD (AODf and AODc) and column Angstrom exponent (AE) to compare with model data. The ensemble model underestimate of AODc relative to observations is larger than the underestimate of AOD while the AODf underestimate is similar to the total AOD underestimate, suggesting models are underestimating coarse mode aerosol. Our results also suggest that models underestimate AE by about 10-20%, which, in contrast, may suggest models simulate larger particles than are observed. However, the complex interplay between AE and multimodal size distributions complicates the interpretation of these AE results, and deserves further attention. The model simulations were also assessed in the context of surface in-situ “dry” aerosol scattering and absorption coefficients from GAW observatories. As with AOD, the models underestimate both of these parameters but exhibit a larger underestimate of aerosol scattering (-35%) than absorption (-20%). This would result in a lower model aerosol single scattering albedo (darker aerosol) than suggested by the observations. A fraction of the scattering underestimate may be due to the definition of dry. Models simulations for this comparison were performed at 0% RH while observations are made at RH<40%. Laj et al. (2020) present model comparisons for climatological scattering and absorption at individual sites in the GAW observing network, but more effort is needed to identify the reasons for the biases observed on a site by site basis. Such effort would also be appropriate for the AERONET sites.

Balkanski, Yves

Aerosol absorption: how dust absorption causes Sahel precipitation

Absorption of shortwave radiation by dust depends on its iron oxides in the form of hematite and goethite. Iron oxides amount to just a few percent of dust mineralogy. In the Sahel, the amount of iron oxide in soils is significantly greater than over the rest of North Africa. Recent measurements from the AER-D campaign have evidenced the presence of large dust particles over Northern African sources, as the Mie theory would predict, measurements of absorption from these large particles show higher shortwave radiation absorbed than for smaller ones. I present two 100-years simulations of the fully coupled earth system model IPSLCM6, one with a detailed description of dust and one without dust. Over the summer months (JJAS), dust absorption amounts to 25 W.m-2 over the region. The changes caused by this absorption to the water budget are analyzed for evaporation, precipitation, surface relative humidity, low-level clouds and total cloud liquid water path, all of which show a significant increase caused by absorbing dust. Just in terms of precipitation, dust absorption causes an increase of 16% of summer Western Sahel precipitation, whereas in the Eastern Sahel, summer precipitation is increased by 7%. We extend this analysis to the water budget over the Sahel region [16W:36E and 10N:20N from the surface to 200mb] and distinguish between the boundary layer and the free troposphere. Dust absorption causes a change in the mean circulation between 1000 and 800mb that induces an increased inflow of moist air at these levels at the western and southern Sahel boundaries during the summer monsoon. Hence, it is important to understand the influence of aerosol absorption when studying the causes of variations in Sahel precipitation.

Bellouin, Nicolas

Impact of Chinese Covid-19 lockdown on aerosol and radiative fluxes over East Asia Marginal Seas

China was the first country to enact regional lockdowns in response to the Covid-19 pandemic. Its lockdown decreased primary and precursor emissions of the industrial and transport sectors over February and March 2020. In terms of aerosols and radiative fluxes, the largest impact occured over the East Asian Marginal Seas, just off the coast of China, where aerosol optical depth decreased by 30% according to MODIS, and reflected solar radiation decreased by 8% according to CERES. Using the GFDL AM4 and UKESM1 climate models, both nudged to reanalysis, we find that changes in emissions explain less than half of the anomaly, the remainder being due to the meteorological conditions prevailing during lockdown. Although the climate model simulations show remarkable consistency with the observations, the two models disagree on the extent of the meteorological influence. This finding is used to provide an observational constraint on the atmospheric residence time of aerosols transported from China.

Bian, Huisheng

Investigation of impact of Amazon fire on forest productivity using an Earth System Model

Amazon experience fires every year. The fire resulted biomass burning aerosols, together with cloud particles, influence the penetration of sun light through atmosphere and redistribute the direct and diffuse light to canopy level for ecosystem productivity. We will present preliminary study of the impact of Amazon biomass burning aerosols on ecosystem via its impact on radiation, as well as the role of the Amazon cloud in adjusting such the aerosol light fertilizer using the NASA GEOS Earth System Model that couples aerosol, cloud, radiation, and ecosystem modules. The study examined the seven-year period of 2010-2016 when Amazon went through important atmospheric dynamic environments (e.g. La Niña, normal years, and El Niño) to cover a potential range of cloud interannual variation.

Bruehl, Christoph

Model simulations of the Pinatubo volcanic eruption: direct and indirect effects on stratospheric chemistry and dynamics

The chemistry climate model EMAC with interactive modal aerosol module is used for simulations of the Pinatubo period 1990 to 1994. Other, smaller volcanic eruptions before and after the major Pinatubo eruption have been included. To estimate the SO2 injections and its 3D distributions, SAGE II L2 satellite data were used. Tropospheric dynamics has been nudged to ERA-Interim meteorological reanalysis data. We show that the reduction of photolysis rates by the volcanic aerosol enhances heterogeneous NOx removal by the volcanic sulphate aerosol, and that the volcanic SO2 plume had a significant effect on ozone production from oxygen photolysis. We further analyze the effect of radiative heating on the vertical transport of species. This includes sensitivity studies on the effects of volcanic ash injected in different size modes, and accounting for chemical aging of these particles.

Burgos, Maria

First global evaluation of the representation of water uptake within ten Earth system models

The uptake of water by atmospheric aerosols has been evaluated by a comprehensive model-measurement evaluation of the particle light scattering enhancement factor, f(RH), within the AeroCom Phase III experiment. The particle hygroscopic growth will have an impact on the optical properties of aerosols and in turn will affect the aerosol-radiation interaction and the calculations of the Earth's radiative balance. The dependence of particle light scattering on relative humidity (RH) can be described by the scattering enhancement factor f(RH), defined as the ratio between the particle light scattering coefficient at a given RH divided by its dry value. The comparison uses simulations from 10 Earth system models (CAM, CAM-ATRAS, CAM-Oslo, GEOS-Chem, GEOS-GOCART, MERRAero, TM5, OsloCTM3, IFS-AER, and ECMWF) and a global dataset of surface-based in situ measurements. This benchmark dataset was generated using a standardized procedure to analyze in-situ scattering measurements at 26 sites around the globe, and it is now accessible via EBAS (http://ebas.nilu.no/). In the present work, modeled and measured scattering enhancement factors are compared for 22 sites, representative of Arctic, marine, rural, mountain, urban and desert aerosols. The models exhibit a large diversity in the simulated f(RH), with a tendency to overestimate the scattering enhancement. Differences in the model parameterizations of hygroscopicity and model chemistry are driving some of the observed diversity in simulated f(RH). Another factor that affects the model evaluation is the definition of dry conditions, pointing to the sensitivity in the model parameterization of hygroscopic growth at low RH (e.g. effects of particle hysteresis). Models show a significantly larger discrepancy with the observations if RH=0% is chosen as the model reference RH compared to when RH=40% is used. Recommendation on updates for hygroscopic growth parameterizations, and new possible experiments to further evaluate the influence of other relevant variables are also proposed. This work is currently in review in ACPD (https://www.atmos-chem-phys-discuss.net/acp-2019-1190/).

Checa-Garcia, Ramiro

Modelling of Mineral Dust in CRESCENDO-ESM

We report the main conclusions of an evaluation of the modelling of mineral dust obtained of CRESCENDO-ESMs. Mineral dust is a key component in the atmosphere due to its interactions with radiation and clouds, as well as, precipitation, soil and chemical components. Earth Systems Models aims to include all those interactions to improve our knowledge of global dust cycle. However, they display important uncertainties and biases when compared against observations. Our study aims to identify those elements of current dust schemes that can be improved over global, regional and local scales. To achieve these goals we compare models against three networks of instruments for total dust deposition flux, yearly surface concentrations, and optical depths. Also we include a comparison with remote sensing products from MODIS, MISR and IASI satellites. We show how the role of larger particles remains challenging, although nudged simulations with surface winds of reanalysis improve the inter-model comparison. We identify regions where differences are larger like Asian deserts or Australia, and we reported important discrepancies regarding wet and dry deposition.

Cheng, Chiu

Development of size-resolving aerosol microphysics scheme for use in a global non-hydrostatic model

To simulate the evolutions of aerosol size distributions and their contributions to the aerosol-radiation and aerosol-cloud interactions, we develop a two-moment sectional aerosol scheme (SPRINTARS-bin) for use in the NICAM global non-hydrostatic atmospheric model coupled with the SPRINTARS aerosol transport model (NCIAM-SPRINTARS). A flexible bin-type size representation is introduced for the major atmospheric aerosol species considered in SPRINTARS: sea salt, mineral dust, sulfate and carbonaceous aerosols. Each size bin is characterized with size-dependent properties such as terminal velocity, CCN property and optical parameters, and mass concentration belonging to each size bin evolves as an independent tracer. For sulfate aerosols, aerosol dynamical processes (new particle formation, condensation and coagulation processes) are represented with explicit size-dependency of the processes. We performed global simulations with SPRINTARS-bin using a GCM-scale resolution and compared to observations, for aerosol properties including AOD and Angstrom Exponent observed by AERONET and MODIS, total particle number concentrations at WMO-GAW sites and size-resolved number concentrations measured at EUSAAR/GUAN sites in Europe. By resolving the fine mode particles and explicitly simulate the size-dependent deposition and transport, SPRINTARS-bin predicts larger values of Angstrom Exponent which better agree with AERONET measurements. While the original model underestimates the total number concentration by a few orders of magnitude, SPRINTARS-bin predicts values within one order of magnitude relative to observations. However, number concentrations of coarse particles are still underestimated by the new model. Further efforts are needed in future studies to better represent the observed size distributions, such as incorporating internally-mixed aerosol species and performing simulations with higher resolutions.

Chimot, Julien

The Copernicus Sentinel-3 Near Real Time (NRT) Aerosol Optical Depth (AOD) Baseline Collection 1 – First release description, quality status and scheduled evolutions by EUMETSAT

In addition to its core marine and continental objectives, the Sea and Land Surface Temperature Radiometer (SLSTR), on board the Sentinel-3 A and B satellites, includes spectral and geometry capabilities to retrieve aerosol properties. On-behalf of the European Commission (EC), EUMETSAT develops and validates the Copernicus Sentinel-3 NRT AOD product. Since end of August 2020, the very first version (i.e. Baseline Collection 1) is publicly disseminated from the EUMETSAT Sentinel-3 Payload Data Ground Segment (PDGS), and the Software Processor v2.0. The product has the following maturity labels: **preliminary operational** for AOD ocean (*i.e.* close to meet user requirements), **demonstrational** for AOD Land (*i.e.* qualitatively good but not yet meeting the user requirements). It is expected to be operationally assimilated by the Copernicus Atmospheric Monitoring Service (CAMS) in a near-future. SLSTR differs from reference aerosol mono-viewing space-borne sensors thanks to its dual-view configuration, like its (A)ATSR predecessors (on-board the ESA ERS and ENVISAT satellites). However, a measurement acquired from only two directional views, regardless the oblique view direction (forward or backward w.r.t. satellite motion), does not equally present a much higher information content everywhere over the globe, than from a mono-viewing sensor. Hence, successful AOD retrieval from any dual-view sensor requires a combination of geometry (dual-angular shape) and spectral constraints to allow a consistent & successful operational worldwide retrieval. This combination overall depends on surface type (ocean, land vegetation, land bare soils), and the acquired configuration geometry across both views. For that purpose, EUMETSAT has focused on aerosol information content & radiometry quality analyses to get the Copernicus Sentinel-3 NRT AOD processor v2.0 applicable globally over ocean and land surfaces, at the resolution of 9.5 km. These analyses notably benefit from:

1) the crucial importance of geometry for EPS-SG, 3MI, MSG, MetOP, SLSTR, AATSR in the aerosol budget error summarised in the recently submitted peer-review paper from B. Fougnie *et al.*, 2020;

2) a dual-view joint land aerosol-surface retrieval method in case of favorable dual-view geometry from the AATSR aerosol algorithm developed by the team of Professor Peter North from the Swansea University (SU) and optimized;

3) A dual-view land aerosol retrieval based on empirical spectral surface constraints in case of unfavorable dual-view geometry, inspired by lessons learned from the Enhanced Deep Blue algorithm team on VIIRS (Sayer et., Hsu et al.).

4) A mono or dual-view ocean aerosol retrieval based on estimated surface reflectance and wavelengths larger than 670 nm;

5) Major lessons learned from the ESA Aerosol Climate Change Initiative (CCI) activities led by Dr. Simon Pinnock as ESA Technical Officer: e.*g.* aerosol models, AOD post-filtering, uncertainty, etc…

6) The preliminary development of the software processor v1.0 by ACRI-ST, Sentinel-3 Mission Performance Centre, via ESA-Copernicus procurement, based on the specification of Prof. Peter North..

7) The SLSTR Aerosol Retrieval Performance (SARP) project, funded and procured by EUMETSAT. Led by the Finnish Meteorological Institute (FMI) as Principal Investigator (FMI).

8) An improved SLSTR absolute, inter-band & dual-view radiometric calibration: based on vicarious calibration over desert sites thanks to a consensus over 4 institutes (RAL, Rayference, CNES, Arizona University), reviewed and approved by EUMETSAT, ESA, SLSTR Quality Working Group (QWG). Today, the validation status shows:

- The global ocean performance retains a very good consistency with MODIS Terra AOD (550 nm) Dark target Ocean Collection 6.1 over open remote oceanic areas, but on average lower values, by ~-0.04, except in case of high dust load.
- The overall performance of the SLSTR NRT AOD (550 nm) over land must firstly be separated between "favourable geometry" (i.e. minimum scattering angle < 110 deg) and "unfavourable geometry" (i.e. minimum scattering angle > 110 deg). The best AOD (550 nm) performance is obtained in case of SLSTR "favourable geometry", occurring mostly on the half Eastern side of both nadir & oblique swaths for all latitudes during Winter time, and in the Southern latitude (i.e. < 20 deg North) for the whole oblique swath during Summer time. Preliminary regional validation with AERONET during Winter time 2019-2020 shows very high correlation over major polluted areas, impacted by heavy industrial / anthropogenic pollution and biomass burning: ~0.91 over India, ~0.74 over Thailand & Australia, ~0.5 over East China, ~0.62 over South-America. Average differences vary between 0.02 (India) and 0.09 (Europe, South-America). However, some limitations are known, such as a positive bias of the order 0.1-0.15 for low AOD (550 nm) values (i.e. < 0.2) and unfavorable geometry, and over hybrid soils (mix of bare soils and vegetation).

The validation of the Copernicus Sentinel-3 NRT AOD product continues between EUMETSAT and the Copernicus Atmospheric Monitoring Service (CAMS). The Sentinel-3 Validation Team (S3VT) Atmospheric sub-group, co-chaired by both EUMETSAT and ESA, has also been invited to extend the evaluation of the AOD Ocean. Improvements thanks to the future V3.0 processor are scheduled for Spring 2021.
Daily monitoring of NRT AOD over oceans from S3A and S3B via the EUMETSAT Monitoring & Evaluation of Thematic Information from Space (METIS) NRT AOD website:
http://metis.eumetsat.int/aod/index.html# (soon available)

Chin, Mian

Progress and results of the AeroCom UTLS experiment

We report the progress and results of the AeroCom UTLS experiments. As of August 2020, there have been three models submitted the output to the AeroCom server: GEOS, SPRINTARS, and GFDL, and another 2-3 models will submit at a later date. We will (1) show model agreement/ diversity at the UTLS region, (2) evaluate the model with multiple satellite data, (3) estimate the source attribution to the UTLS aerosols, particularly over the area affected by the Asian Summer Monsoon transport, and (4) discuss next steps.

Chubarova, Natalia

Urban aerosol and its radiative effects in Moscow Megacity according to the ground-based and satellite (MODIS/MAIAC) measurements, and COSMO-ART modelling

We analyzed the urban aerosol properties using the results of the AeroRadCity urban aerosol experiment during spring 2018 and 2019, which included the intensive measurement campaign at the Moscow State University Meteorological Observatory and parallel model simulations using chemical transport COSMO-ART model (Vogel et al., 2010) as well as satellite aerosol optical depth (AOD) retrievals using MODIS-MAIAC dataset for the 2000-2017 period over Moscow megacity. We showed different types of the surface/columnar aerosol dependence under various meteorological conditions, and the interaction of columnar aerosol absorbing properties with black carbon aerosol measurements only in conditions with high level of particle dispersion intensity. Model and experimental data demonstrated positive BC relationships with PM10, NO_2 and SO_2. The analysis of radiative effects of aerosol in the clear sky atmosphere has revealed up to 30% loss for UV irradiance and 15% - for shortwave irradiance at high AOD with larger attenuation in conditions of elevated boundary layer (Chubarova et al., 2019). Negative (cooling) RF effect at TOA varied from -20 Wm-2 to -1 Wm-2 with average of -8 Wm-2. The application of the MAIAC algorithm over the whole Moscow region has revealed a decreasing AOD trend over the center of Moscow and an increasing trend over the “New” Moscow territory, which experienced an intensive build-up and agricultural development. According to the MAIAC dataset, the most pronounced spatial AOD differences (of about 0.05–0.06) were observed at the 5% quantile level over several locations and could be attributed to the stationary sources of aerosol pollution (Zhdanova et al., 2020). For the ground-based AERONET measurements, the difference (deltaAOD) between median aerosol optical depth at the Moscow_MO_MSU and at the background Zvenigorod site has a statistically significant positive bias for most years, and an average deltaAOD of about 0.02 while according to the MAIAC dataset, the deltaAOD varied within 0.01 and was not statistically significant. The urban AOD550 calculations using the COSMO-ART model have shown a difference of about dAOT= 0.017 between Moscow and Zvenigorod in clear sky conditions in accordance with measurements, but have a significant overestimation in the cloudy atmosphere. This research has been supported by the Russian Science Foundation (grant no. 18-17-00149).

Possible mechanism of the increase in solar irradiance cloud transmittance and decrease in cloud cover over Europe due to

negative trends in sulphate aerosols: a study with the INMCM5 climate model

We showed that according to the Era-Interim re-analysis data there is a pronounced effect of cloud transmittance increase over Europe during warm period since the end of 1970s (Chubarova et al., 2020). In this study using the reconstruction model and routine cloud observations we demonstrate that the main reason of these changes is the decrease in low layer cloud cover. At the same time, there is a pronounced negative trend in sulphate aerosol optical thickness over this period in this region. Using INM RAS model with 2 x 1.5° resolution (Volodin et al., 2017) with the aerosol module described in (Volodin and Kostrykin, 2016) we made several numerical experiments for evaluating the possible role of indirect effects of hydrophilic sulphate aerosols on solar irradiance cloud transmittance trends. The influence of different parametrizations of aerosol-cloud-interaction was studied. The results have revealed that during warm period the account for non- direct aerosol effect provides a better agreement in cloud solar irradiance transmittance trends over Europe with those obtained from the Era-Interim reanalysis data. We discussed the possible causes of the observed effects. This research has been supported by the Russian Science Foundation (grant no. 20-17-00190).

Colarco, Peter

The Multi-Model International Cooperative for Aerosol Prediction (ICAP) Perspective on the Massive June 2020 Saharan Dust Event

During June 2020 a massive Saharan dust event propagated across the Atlantic Ocean and produced high aerosol optical depth (AOD) and surface particulate matter (PM) concentrations across the Caribbean and US gulf coast states that were far above climatological means. Ground-based measurements of PM, AOD, light scattering, absorption and visibility taken in the Greater Caribbean Region during the summer 2020 NASA-funded Caribbean Air-quality Alert and Management Assistance System-Public Health (CALIMA-PH) motivated a close look at predictive aerosol models that were forecasting dust plumes. The occurrence and progression of the June 2020 event was predicted by various global numerical weather prediction (NWP) centers that have included prognostic aerosols in their forecasting systems. Collectively, the centers represented in this study are contributing members of the International Cooperative for Aerosol Prediction (ICAP), a grass-roots community of model developers, data providers, and NWP center representatives. Eight models contributed forecasts to the ICAP multi-model ensemble (MME) during this event: the Barcelona Supercomputing Center, European Centre for Medium-Range Weather Forecasts, Japan Meteorological Agency, Finnish Meteorological Institute, NASA Goddard Space Flight Center, US National Centers for Environmental Prediction, UK Met Office, and US Navy Research Laboratory. We put this Saharan dust episode and the prevailing meteorological conditions in the context of model analyses and ground and space based observations taken over the course of the event, and we provide an evaluation of the individual ICAP models and the ICAP MME forecast and analysis performance in simulating the observed AOD and PM.

Douglas, Alyson

Understanding changes in warm cloudiness since pre-industrial times using machine learning of satellite observations

Cloud adjustments, including how aerosol-cloud interactions lead to changes in cloud extent, remain uncertain and difficult to model using GCMs. Utilizing a random forest and stochastic gradient boosting, the change in cloud fraction due to aerosol can be inferred from global, marine observations of warm clouds. The simple machine learning models are trained to estimate a pristine cloud fraction based on the environmental features, leading to a pristine cloud fraction estimate in polluted scenes. The difference between the pristine estimate and the actual, polluted cloud fraction can be inferred to be the change in cloudiness due to aerosol-cloud interactions. I show that these models are physically realistic, able learn their own constraints, and lead to cohesive global patterns of changes in cloudiness. The global change in cloud fraction due to aerosol-cloud interactions in warm clouds may be a 2.4% increase, leading to over 1.4 W/m2 of cooling.

Dubovik, Oleg

Validation of GRASP algorithm product from POLDER/PARASOL data and assessment of multi-angular polarimetry potential for aerosol monitoring

Based on the multiple results of theoretical and practical studies, multi-angular spectral polarimetry is considered as a type of satellite observations that is most appropriate for comprehensive retrieval of properties of aerosols. Furthermore, a large number of advanced space polarimeters have been launched recently or planned to be deployed in a few coming years for assuring adequate monitoring of the atmospheric aerosols (Dubovik et al., 2019). Nevertheless, at present, practical utilization of aerosol products from polarimetry is rather limited. This situation is certainly due to the relatively small amount of polarimetric observations compared to photometric observations but it is also the result of the challenges in obtaining the extensive product due to the general complexity of polarimetric observations and theory. Indeed, while in recent years several algorithms of new generation have been developed to provide enhanced aerosol retrievals from satellite polarimetry, the practical value of available aerosol products from polarimeters yet remains to be proven. In these regards, this paper presents the analysis of aerosol products obtained by the Generalized Retrieval of Atmosphere and Surface Properties (GRASP) algorithm from the POLDER/PARASOL observations. The objective of this study is to comprehensively evaluate the GRASP aerosol products obtained from POLDER/PARASOL observations. First, the validation of the entire 2005 - 2013 archive was conducted versus Aerosol Robotic Network (AERONET). The subjects of the validation are spectral aerosol optical depth (AOD), aerosol absorption optical depth (AAOD) and single scattering albedo (SSA) at 6 wavelengths, as well as Ångström exponent (AE), fine mode AOD (AODF) and coarse mode AOD (AODC) interpolated at reference wavelength 550 nm. Second, an explicit inter-comparison of the PARASOL/GRASP was conducted with the PARASOL/Operational, MODIS Dark Target (DT), Deep Blue (DB) and Multi Angle Implementation of Atmospheric Correction (MAIAC) aerosol products for the year 2008. Specifically, the validation against AERONET was consistently performed for each product and the obtained validation metrics were compared. In addition, PARASOL and MODIS products were inter-compared globally. Overall, the analysis suggests that AOD retrieval from the multi-angular polarimetric observations, like POLDER, and mono-viewing MODIS-like imagers can be expected, at least, of the comparable quality. At the same time, the multi-angular polarimetric observations are to be able to provide more information on detailed aerosol properties, including spectral AODF, AODC, AE, as well as additional aerosol parameters such as AAOD and SSA.

Eck, Thomas

Analysis of AERONET Extended Wavelength Retrievals of Aerosol Absorption Parameters Including 380 nm and 500 nm for Detection of Brown Carbon in Biomass Burning and Iron Oxides in Desert Dust

We have been conducting ongoing research and analysis of AERONET retrievals of spectral imaginary refractive index and size distributions with the input of data from additional wavelengths. This includes adding both measured spectral AOD and sky radiances at 380 nm and 500 nm to the four channels (440, 675, 870 and 1020 nm) that have been input to the standard retrieval data product. The vector radiative transfer code in the AERONET Version 3 retrievals enabled more accurate computations in the ultraviolet region (380 nm). Calibration of the 380 nm channel radiances was done by the vicarious method since the integrating sphere radiance source that is used for all other wavelengths does not produce sufficient energy at 380 nm. Spectral single scattering albedo (SSA), imaginary refractive indices and aerosol size distributions from these six wavelength retrievals are compared to the standard four wavelength retrieval values. For coarse mode dominated observations of desert dust aerosol, the 6 channel retrievals show enhanced absorption by iron oxides at 380 nm. Dynamics of the dust spectral absorption are examined for selected sites located downwind of major dust sources. Variation of absorption magnitude as a function of AOD levels, day of year (seasonal) and for some selected cases differences related to specific source regions inferred by back trajectories. Comparisons to recently published spectral SSA of desert dust in various regions are shown. For selected biomass burning regions in the mid-latitudes and tropics the retrievals of fine mode dominated aerosol show enhanced absorption at 380 nm and 440 nm relative to 500 nm, consistent with expected brown carbon absorption in these wavelengths from organic particles. The inclusion of the 500 nm input data and inversion results are important as this allows for better quantification of enhanced brown carbon absorption in the short wavelength visible and UV-A region, while black carbon alone dominates the absorption from the mid-visible through the near-infrared wavelengths. Some preliminary comparisons to other retrieved and measured aerosol spectral SSA and imaginary refractive indices from tropical biomass burning regions are shown. The size distribution retrievals for fine mode dominated cases show minimal differences between the standard four wavelength and the new six wavelength retrievals.

Espinosa, Reed

Exploring the capabilities of synergistic passive and active remote sensing with a new aerosol retrieval testbed

The present generation of space-based instrumentation generally permits measurements spanning the majority of the shortwave spectrum, or observations at multiple viewing angles, but rarely both.

Moreover, very few of these instruments possess sensitivity to polarization, and those that do lack the accuracy and resolution required to fully utilize this quantity. This limited information content generally confines current operational aerosol retrievals to only a few parameters, like aerosol optical depth and fine-mode fraction. In the next decade, a variety of satellites are expected to launch with sensors that will exceed these current observational limitations, including platforms that will make coincident measurements of polarimetric radiances with atmospheric profiles of backscatter, extinction, and depolarization from LIDAR. Increased information content in these new datasets is expected to drive significant improvements in aerosol remote sensing capabilities but, if this additional information is to be fully utilized, novel retrieval approaches will have to be developed and evaluated. In this work, observationally constrained surface parameterizations and aerosol models are used to simulate realistic top-of-atmosphere polarimetric radiances as well as elastic and inelastic backscatter profiles. These synthetic observations are fed into the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm and the resulting inversion products are compared with the aerosol state parameters used to produce the simulated observations (i.e. the modeled "truth") in order to obtain estimates of retrieval uncertainty for different instrument and retrieval configurations. This new testbed is used to assess inversion capabilities under various observation scenarios, with an emphasis on the retrieval improvements afforded by polarization and the inclusion of LIDAR profiles. Special attention is paid to cases where the aerosol assumptions modeled by the retrieval diverge from the particle properties used in the forward modeling of the simulated scenes. In the context of polarimetric measurements, it is found that errors in the retrieval forward model can significantly impact retrieval performance, especially incorrect assumptions regarding coarse and fine mode particle shape.

Fadnavis, Suvarna

Elevated aerosol layer over South Asia worsens the Indian droughts

Droughts have become more severe and recurrent over the Indian sub-continent during the second half of the twentieth century, leading to more severe hydro-climatic and socio-economic impacts over one of the most densely populated parts of the world. So far, droughts have mostly been connected to circulation changes concomitant with the abnormal warming over the Pacific Ocean, prevalently known as "El Niño". Here, exploiting observational data sets and a series of dedicated sensitivity experiments, we show that the severity of droughts during El Niño is amplified (17%) by changes in aerosols. The model experiments simulate the transport of boundary layer aerosols from South Asian countries to higher altitudes (12–18 km) where they form the Asian Tropopause Aerosol Layer (ATAL) (~ 60–120°E, 20–40°N). During El Niño, the anomalous overturning circulation from the East Asian region further enriches the thickness of aerosol layers in the ATAL over the northern part of South Asia. The anomalous aerosol loading in the ATAL reduces insolation over the monsoon region, thereby exacerbating the severity of drought by further weakening the monsoon circulation. Future increases in industrial emissions from both East and South Asia will lead to a wider and thicker elevated aerosol layer in the upper troposphere, potentially amplifying the severity of droughts.

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 CALIOP and NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidar 2 measurements to characterize extensive 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, 2017, and 2018. HSRL-2 measured profiles of aerosol backscattering, extinction, aerosol optical depth, and depolarization at 355 and 532 nm and aerosol backscattering and depolarization at 1064 nm. We also use these profiles in advanced retrieval algorithms to derive profiles of aerosol effective radius and concentration.
The HSRL-2 aerosol profiles show that the vertical distributions of these smoke layers varied during these deployments. 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 that indicate aerosol properties such as particle size and/or absorption varied with altitude. HSRL-2 measurements showed a more pronounced gap between the smoke and cloud layers in 2016 than in 2017 and 2018 and that this gap depends heavily on the threshold used to define the gap. These data also show no correlation between above cloud AOD and aerosol extinction just above the cloud top. We compute aerosol extinction and backscattering profiles 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, which were computed for the period 2006-2018, provide more accurate ACAOD values and aerosol extinction profiles than the CALIOP V4 operational retrievals. These profiles show that the height of the bottom of the smoke layer and the cloud top height increase with distance from the coast and that the aerosol extinction just above the cloud decreases with distance from the coast. We also use these CALIOP above cloud aerosol extinction profiles to assess MERRA-2 reanalysis profiles over this same period and region.

Fougnie, Bertrand

How consider the geometry of acquisition on the aerosol retrieval performance

The geometry of acquisition is an important aspect to be consider when evaluating the ability to retrieve the aerosol properties from space. We describe for various cases the geometry of acquisition, the consequence on the measured aerosol signal, and the potential impact on the ability to retrieve their properties. A series of recommendations are drawn about the need to document this aspect, to report it on quality index parameters, and to consider it on the validation of aerosol products.

Garrigues, Sebastien

AOD monitoring within the CAMS data assimilation

AOD monitoring within the CAMS data assimilation can be used as a starting point for further discussion on the key topic of intercomparing satellite AOD and evaluating them against ground observations

Gettelman, Andrew

Natural Laboratories for Aerosol Cloud Interactions- Simulating Aerosol Cloud Precipitation and Climate interactions (ACPC)

This presentation will review ongoing work of the Natural Laboratories group of the Aerosol Cloud Precipitation and Climate (ACPC) project and how modeling can help inform and benefit from work using natural laboratories like volcanoes, shipping and industrial sources to understand ACI processes. The work includes modeling and observations.

Gliss, Jonas

Aerocom Phase III model diversity and comparison with AP1

Within the framework of the AeroCom initiative, output from 14 global aerosol models participating in the Phase III control experiment has been used to assess the modelling of aerosol optical properties (Gliss et al., ACPD, 2020). Here, we provide an inter-model ensemble overview of the diversity in globally averaged emissions, deposition, lifetimes, burdens as well as mass-extinction and mass-absorption coefficients (MECs, MACs) and optical depths (ODs) for each model and aerosol species. In Aerocom Phase III, the nitrate simulation exhibits the highest diversity, particularly for emissions and burden, but only 9 models include this species. For sea salt and dust the highest diversity is related to their modelled lifetime, with sea salt exhibiting greater lifetime diversity than dust. OA diversity is highest in terms of simulated OD and emissions, while the least diversity is observed for MEC. This suggests inter-model discrepancies in emissions and life time leading to mass loading are more important for organic aerosols than the conversion from mass to optical property. As compared to OA the sulfate simulation diversity is slightly larger except for the sulfate formation term and the sulfate OD. This Phase III inter-model evaluation is followed by a comparison with results reported for the AeroCom Phase I assessment (e.g., Textor et al., 2006; Kinne et al., 2006) to highlight changes in the last 15 years. Looking at the historical comparison between Phase I and Phase III results, we find that AOD is about the same for both experiments but the relative proportions of species contributions have changed. Notably, the total contribution of natural aerosol (sea salt + dust) is about the same for Phase I and Phase III, but sea salt now contributes ~2/3 of the natural aerosol OD whereas in Phase I sea salt and dust contributed approximately equally to the natural aerosol OD. This change is likely due to a change in assumptions about sea salt size distributions combined with a decrease in dust emission strength and lifetime. Sulfate and OA OD are about the same for both Phase I and Phase III. BC OD in Phase III is about ½ of what it was in Phase I.

Gryspeerdt, Edward

Identifying observational constraints on aerosol-cloud interactions

Observed relationships between aerosol and cloud properties are often used as constraints on aerosol-cloud interactions. Even with perfect retrievals of these properties, meteorological factors, such as relative humidity and wet scavenging can confound these relationships, obscuring the causal impact of aerosol on cloud properties. In this work, we use results from the AeroCom indirect effect experiment together with the E3SM perturbed parameter ensemble to investigate the ability of these observed relationships to constrain aerosol-cloud interactions. With a particular focus on cloud adjustment, we compare observational relationship to their equivalents in global models. By comparing the ``diagnosed'' cloud adjustments with the actual values from the same models, we identify the conditions under which observed relationships are best able to constrain aerosol-cloud interactions.

Hahn, Valerian

Increased shortwave reflectance at the top of atmosphere by continental polluted low-level clouds in tropical West Africa during the DACCIWA campaign

During the West African summer monsoon, ubiquitous tropical continental low-level clouds are considered to exert an important role on the radiative budget. Detailed ground based observations of microphysical cloud parameters or in situ data acquisition from this region are rare and additionally often obscured by the presence of mid-level and high clouds in respect to passive satellite data.
The strong economic growth in tropical West Africa projects a steady increase in aerosol emissions and cloud condensation nuclei concentrations in the boundary layer, which in theory should affect cloud microphysical parameters. Nevertheless, tropical low-level clouds are still poorly represented in global weather models.
Here, we present comprehensive in situ measurements of microphysical properties of low-level clouds over tropical West Africa, measured with the DLR Falcon 20 during the DACCIWA (Dynamics–aerosol–chemistry–cloud interactions in West Africa) campaign in June and July 2016. These data will be used to quantify the net radiative forcing of low clouds on the basis of in situ measurements in a first estimate. The moderate to substantially polluted tropical continental low-level clouds reveal mean droplet number concentrations near 400 cm-3 and effective droplet radii of 6 to 8 µm. We show that higher cloud condensation nuclei concentrations in the polluted city outflow and in the agglomerations further inland reflect in a 50% increase in the cloud droplet number concentration and a 34% decrease in effective particle size, while low mean updraft speeds and high biomass burning aerosol background entrained from Central Africa limit this sensitivity. Simulations with the radiative transfer package libRadtran show a non-negligible influence of droplet number concentrations in polluted-, compared to less polluted low-level clouds on the net radiative forcing at the top of atmosphere. However, the presence of high background aerosol concentrations and the occurrence of additional mid and high-level clouds buffers this effect, so that a net heating rate and radiative forcing of low-level clouds might be less sensitive towards future increases in anthropogenic pollution in West Africa.

Hasekamp, Otto

Retrieval of Cloud Condensation Nuclei to Quantify the Radiative Forcing due to Aerosol Cloud Interactions

Aerosols serve as cloud condensation nuclei (CCN) and thereby affect the cloud droplet number concentration (Nd) and consequently cloud albedo. This effect, known as the radiative forcing due to aerosol-cloud interactions (RFaci) is one of the largest contributors to the uncertainty in estimates of anthropogenic forcing of climate change. Satellite studies of aerosol-cloud interactions are almost solely based on relationships between aerosol optical properties and Nd. This leads to considerable uncertainties because optical properties are not directly related to CCN capability. In this study, we use recent satellite retrievals of aerosol size distribution, shape, and column number from the POLDER-3 instrument to provide a better CCN proxy, Nccn. From relationships between Nccn retrieved from POLDER and Nd retrieved from MODIS, we find that that the CCN capability of aerosols depends strongly on aerosol size and shape. Using the POLDER-3 derived Nccn we find much stronger aerosol-cloud interactions than previous observation based studies using optical properties.

Herbert, Ross

Understanding the Asian summer monsoon response to a future dipole in aerosol emissions across India and China using an intermediate-complexity GCM

Anthropogenic aerosol emissions from India and China impact the Asian summer monsoon circulation and rainfall patterns. Historically, aerosol and precursor emissions have increased in India and China, weakening the summer monsoon. The Shared Socioeconomic Pathways (SSPs) explore a range of aerosol emission scenarios in India and China, including a continuation of the strong dipole pattern observed since 2010. Such a dipole pattern may result in marked changes to the aerosol fingerprint on the monsoon, but the mechanism for such a response has not yet been explored in depth. The IGCM4, an intermediate-complexity general circulation model, is able to reproduce large-scale atmospheric circulation patterns including the Asian monsoon system at low computational expense, providing a novel tool for understanding how the climate responds to specific perturbations. We use the IGCM4 to investigate the impact of the aerosol emission dipole on the Asian summer monsoon with observationally constrained aerosol profiles over India and China. Our results are able to isolate the impact that aerosol emissions (either scattering or absorbing) have in both regions, and provides insight into how future emission patterns may impact the monsoon.

Hotta, Haruka

Evaluation of Cloud-Aerosol Interactions Using the Cloud System Resolving Model NICAM-SPRINTARS and Satellite Observations.

Conventional climate models have a fundamental difficulty in representing cloud processes accurately due to their coarse resolutions, leading to a large uncertainty in the evaluation of the climate impact of

aerosol-cloud interactions. On the other hand, recent progress in global high-resolution modeling such as NICAM coupled with the aerosol model SPRINTARS [Suzuki et al. 2008] enabled us to represent cloud and aerosol processes more explicitly on a global scale and thus to investigate their interactions in a process-based manner. A recent study using NICAM-SPRINTARS with a horizontal resolution of 14 km [Sato et al. 2018] showed that the model reproduced a negative correlation between aerosol numbers and cloud water content consistent with satellite observations. However, the one-moment cloud microphysics scheme used [Tomita 2008], predicting only mass concentrations of hydrometeors, may still fail to represent the key processes that are critical in shaping cloud-aerosol interactions.
This study coupled a two-moment microphysics scheme [Seiki and Nakajima 2014] with aerosol processes in NICAM-SPRINTARS to evaluate how aerosol-cloud interactions are represented differently between the one- and two-moment microphysics schemes in the framework of the global cloud-system-resolving model. In contrast to the previous hypothesis based on the one-moment scheme, our analysis with the two-moment scheme shows that wet deposition significantly contribute to the formation of the negative correlation and that the cloud lifetime effect is weaker in the two-moment scheme due to larger contributions of the accretion process.

Jafariserajehlou, Soheila

PMAp: synergistic global Aerosol product from Metop satellites

Aerosol particles have an important influence on the earth's climate system, human health, renewable energies, and air traffic. Satellite observations offer the excellent capability to retrieve and monitor aerosol distribution and transport regularly at a global scale that are major concerns to the scientific community as well as policymakers. Polar Multi-sensor Aerosol product (PMAp) provides near real-time aerosol parameters (e.g. aerosol optical depth and type) at a global scale over both land and ocean, under clear-sky, as well as partially cloudy conditions. It uses the data from Metop that implements the EUMETSAT Polar System (EPS) programme as a series of three polar-orbiting satellites. PMAp is based on a synergetic aerosol retrieval approach that exploits the combination of observations from different sensors onboard Metop: i) the reflectance and polarization measurements of 2nd Global Ozone Monitoring Experiment (GOME-2) to retrieve aerosol optical properties; ii) the observations from the Advanced Very-High Resolution Radiometer (AVHRR) with the high spatial resolution and wide spectral range to provide information about sub-pixel cloud coverage and the split-window technique to detect dust/ash; iii) the fine structure of the Infra-red Atmospheric Sounding Interferometer (IASI) to retrieve SO2 plumes and discriminate between dust and ash layers. The final product is at the spatial resolution of 40 km x 5 km for Metop-A (960 km swath), 40 km x 10 km for Metop-B, and C (1920 km swath). In addition to aerosol, PMAp provides cloud parameters (e.g. cloud optical depth and cloud top temperature). Here we present the latest version of PMAp and different case studies of aerosol optical depth and type from dust plumes, fires, or other strongly polluting events. In addition, we show the comparison of PMAp to other aerosol products e.g. Sentinel-3 AOD.

Johnson, Ben

Self-raising aerosol

The vertical distribution of aerosol is important for its radiative effects and interaction with clouds absorbs solar radiation, yet absorbing aerosols have their own way of staying aloft. By absorbing solar radiation the black carbon component of aerosol mixtures enhances their buoyancy enabling them to reach higher altitudes in the atmosphere. This may be more important in global aerosol transport than initial factors, such as the degree of plume rise at the point of emission. For instance, in HadGEM3 absorption-lofting doubles the concentration of BC in the upper troposphere and more than doubles the loading of carbonaceous aerosol over remote oceanic regions. The enhanced elevation of biomass burning aerosol layer may also be pivotal in certain regions, such as the Southeast Atlantic. We have been puzzled for some time as to why some models fail to keep these aerosol layers at height, allowing the aerosol to entrain to quickly into the stratocumulus-filled marine boundary layer. Could underestimation of aerosol absorption play a role?

Kahn, Ralph

AeroSat update for the AeroCom meeting

Update on the AeroCom wildfire plume-height experiment

Kauppi, Anu

Studying aerosol type selection and retrieved AOD estimates when applied to TROPOMI measurements

We present preliminary results when studying aerosol type selection and retrieved AOD estimates with uncertainties in LUT-based approach using S5P/TROPOMI reflectance measurements. This study continues the earlier work done using OMI measurements and the retrieval methodology is based on Bayesian inference. We have constructed the LUTs using libRadtran simulations. The aerosol properties for radiative transfer calculations are intended to be the same as in OMI case but we have also included some new aerosol microphysical models. We consider here the uncertainty due to model selection and due to approximations in forward modelling. The focus in this presentation is to demonstrate the aerosol LUT selection procedure and the resulting AOD estimates by example cases that cover different aerosol events.

Kim, Dongchul

Accessment of dust source attribution to the global land and ocean regions

The major source of global dust is well established as most of them are originated from a few major source regions of North Africa, Middle East, and Asia which accounting for more than 80% of global dust emssion. However, it is more difficult to attribute the source contribution when they are mixed during the inter-continental long-range transport. From the AeroCom model simulations, the goal of this study is to investigate the source-receptor relationships over land where affected by both local and transported dust; and remote- and ocean-regions where only contributed by long-range transport, including Arctic, Antarctic, Tibetan Plattau, Mid-Pacific, Mid-Atlantic, and Upper Troposphere. A series of runs with 9 tagged regions were made to estimate the contribution of East- and West-Africa, Central- and East-Asia, North America, and the Southern Hemisphere, including 3 prominent dust hot spots of the Bodele, Middle East, and Taklimakan Deserts. In this work, we will (1) estimate the contribution of dust from different source regions to various land and ocean receptor regions, (2) assess the change of simulated dust size distribution between source and receptor regions. (3) compare the dust optical depth between mid-visible (550 nm) and thermal infrared (10 μm) wavelengths.

Kim, Paul

AeroCom Trajectory Experiment (GCMTraj): Lagrangian analysis of aerosol life cycle processes in GCMs

The AeroCom Trajectory Experiment (GCMTraj) aims to perform a multi-model evaluation of the aerosol life cycle using a trajectory-based Lagrangian framework to isolate source and sink processes during transport. This evaluation will be used to better understand what drives the discrepancies between modelled and observed aerosol microphysical properties at ground-based measurement stations in different environments. Measurement station observations linked to reanalysis trajectories are used to evaluate each GCM with respect to a quasi-observational standard to assess GCM skill. Using GCM output spatially and temporally collocated along GCM derived trajectories, the evolution of simulated aerosol and cloud properties can be thoroughly examined to identify key processes to target to improve GCM representation of aerosol properties. With the development phase of the experiment completed, the experiment details are now finalised and analysis using longer term GCM and observational datasets is ongoing. In this presentation I will discuss the initial results from the 'core' phase of the experiment and summarise the principal techniques for investigation which are being applied in the analysis. The evaluation of collocated aerosol source (e.g. emission and secondary formation) and sink (e.g. wet/dry removal and activation of aerosols into cloud droplets) processes during transport will be shown and the impact these processes have on the simulated aerosol burden will be highlighted in pristine Arctic, boreal and marine environments. This enables quantification of the contribution of source and sink processes to discrepancies with observed aerosol, providing detailed metrics for GCM evaluation and development. The evolution of aerosol microphysical properties during transport in GCMs will be analysed using collocated aerosol particle number size distributions which provide information on growth via condensation and coagulation. Some preliminary analysis into aerosol-cloud interactions and the impacts of cloudy vs. non-cloudy transport will also be discussed. The benefits of a Lagrangian analysis approach for improving the understanding of the drivers behind inter-model and model-observation discrepancies will be demonstrated.

Knobelspiesse, Kirk

Analysis of simultaneous aerosol and ocean glint retrieval using multiangle observations

Since early 2000, NASA's Multi-angle Imaging SpectroRadiometer (MISR) instrument has been performing remote sensing retrievals of aerosol optical properties from the polar orbiting Terra spacecraft. A noteworthy aspect of MISR observations over the ocean is that, for much of the Earth, some of the multi-angle views have contributions from solar reflection by the ocean surface (glint, or glitter), while others do not. Aerosol retrieval algorithms often discard these glint contaminated observations because they overwhelm the signal and are difficult to predict without knowledge of the (wind speed driven) ocean surface roughness. Other algorithms directly use the sun glint to determine the ocean surface roughness, and by extension wind speed, but do not simultaneously retrieve aerosol optical properties. However, theoretical studies have shown that multi-angle observations of a location at geometries with and without reflected sun glint can be a rich source of information, sufficient to support simultaneous retrieval of both the aerosol state and the wind speed at the ocean surface.
We are in the early stages of creating such an algorithm. In this presentation, we describe our assessment of the appropriate level of parameterization for simultaneous aerosol and ocean surface property retrievals using sun glint. For this purpose, we use Generalized Nonlinear Retrieval Analysis (GENRA), an information content assessment (ICA) technique employing Bayesian inference, and simulations from the Ahmad-Fraser iterative radiative transfer code.

Kokkola, Harri

Identifying the model properties contributing to aerosol forcing uncertainty

Recently, new approaches have emerged where model sensitivity to different processes is analyzed by perturbing model properties and analyzing the model response. However, these sensitivities are model dependent and thus such model experiments provide info only on individual models. Instead, we propose a new way to understand the uncertainty in aerosol forcing. This is done using data from multi-model experiments by applying a model analysis tool which includes routines for calculating aerosol-radiation interactions and aerosol-cloud interactions offline. In the analysis tool, 3D fields of any climate model can be used interchangeably. Interchanging the model fields, and then calculating the resulting aerosol effects offline, we obtain how much each of model properties (aerosol properties, atmospheric properties, and model internal properties) cause variability in aerosol-radiation interactions and aerosol-cloud interactions. Using this climate model analysis tool, we can pinpoint, which of these properties cause highest local and global variability on aerosol radiative forcing. The benefit of this approach is that it can use data from already-existing model simulations.

Kondragunta, Shobha

China and Taiwan: A Tale of Two COVID-19 Lockdown Measures and Air Quality Impacts

China placed a total lockdown measure to contain the novel coronavirus (2019-nCoV, referred to as COVID-19) that originated in Wuhan, Hubei province, in late January 2020. As the virus spread out of China across the world, many countries placed similar lockdown measures, either total or partial, to contain the spread of the virus. Taiwan did not implement any major lockdown measures. Instead, it contained the spread of the virus by aggressively screening and limiting international travelers. Due to these disparate measures between China and Taiwan, the impact on the environment was also drastically different. Most countries had an unexpected benefit of clean air during the lockdown due to reduced urban/industrial emissions. Most of Asia in the winter time experiences smog due to emissions from vehicles, industry, and long-range transport. The long-range transport is generally from biomass burning aerosols released from agricultural land clearing or wildfires and in some instances dust storms. In 2020, during March and February, air quality in Hubei province became relatively pristine; surface PM2.5 (particles smaller than 2.5 µm in median diameter) measurements made at Chengdu station showed that highest concentration was 102 µg/m3 compared to 1000 µg/m3 in 2019. In contrast, Taiwan did not experience any substantial reductions in particle concentrations and air quality. February and March are also the months where there is no significant transport of pollution from mainland China to Taiwan. Satellite observations of aerosol optical depth (AOD) from Suomi NPP Visible Infrared Imaging Radiometer Suite (VIIRS) show the same behavior, mainly reduced levels of AOD in 2020 compared to climatology in Hubei province in China and no significant difference between 2020 and climatology in Taiwan. The Nitrogen Dioxide (NO2), key precursor for ozone and aerosols, observed from Sentinel 5P Tropospheric Ozone Monitoring Instrument (TROPOMI) and Suomi NPP Ozone Mapping and Profiler Suite (OMPS) also show similar patterns as observed by AOD. This presentation will compare and contrast the satellite observations of NO2 and AOD in February and March 2020 between China and Taiwan to illustrate how two regions with different lockdown measures experienced the impact differently.

Kramer, Ryan

Observed aerosol forcing trends over the A-Train satellite era

The radiative imbalance at the top of the atmosphere is driven by both radiative forcing and the climate's intrinsic radiative response. While the Clouds and Earth's Radiative System (CERES) satellite platform has provided continuous measurements of this total imbalance for roughly two decades, the relative contribution of these terms is not immediately distinguishable. To separate them, we apply radiative kernels to a suite of satellite observations over the A-Train era. We find radiative forcing has increased 0.53 +/- 0.11 W/m2 globally, accounting for essentially all of the long-term trends in the total radiative imbalance from 2003 through 2018. We find roughly 0.1 +/- 0.05 W/m2 of this increase stems specifically from aerosol forcing. Viewed locally, it becomes apparent this trend is largely explained by reductions in anthropogenic aerosol emissions over the world's major source regions. We discuss how this approach could be used to monitor the climate impacts of aerosol emissions in near real-time.

Lipponen, Antti

Model Enforced Post-Process Correction of Satellite Aerosol Retrievals

Oversimplified assumptions and approximations used in the retrieval algorithms often cause biases and uncertainties to the satellite aerosol data products—examples of such assumptions and approximations include unknown surface reflectance or fixed aerosol models. Furthermore, the retrieval algorithms do not usually take advantage of all the possible observational data collected by the satellite instruments and may, for example, leave some spectral bands unused. We have developed a model enforced post-process correction approach that can be used to correct for the existing and operational satellite aerosol data products. Our approach combines the existing satellite aerosol retrievals, and a post-processing step carried out with a machine learning-based correction model for the approximation error in the retrieval. The developed approach allows for the utilization of auxiliary data sources, such as meteorological information, or additional observations such as spectral bands unused by the original retrieval algorithm. The post-process correction model can learn to correct for the biases and uncertainties in the original retrieval algorithms. As the correction is carried out as a post-processing step, it allows for a computationally efficient re-processing of existing satellite aerosol datasets with no need to fully re-process the much larger original radiance data. We demonstrate with over land aerosol optical depth (AOD) and Angstrom exponent (AE) data from the Moderate Imaging Spectroradiometer (MODIS) of Aqua satellite that our approach can significantly improve the accuracy of the satellite aerosol data products and reduce the associated uncertainties.

Litvinov, Pavel

Surface and aerosol retrieval from S5P using GRASP: baseline requirements and expected performance

Sentinel-5p instruments provide hyperspectral measurements in UV, VIS and infrared spectral range. Though the main purpose of the satellite is trace gas characterization, it's capable of aerosol and surface characterization. In particular, S5p measurements in UV have unique information about absorption and elevation properties of aerosol. Moreover, measurements in wide spectral range are very sensitive to aerosol size and surface type. On one hand, aerosol and surface characteristics are important input parameters for different trace gases such as ozone, NO2, BrO, CH2O, H2O, CO2, CO, and CH4. On another hand, aerosol and surface characteristics are very important on their own for climate studies, air pollution and surface monitoring. Here on the basis of GRASP inversion results from S5p measurements we discuss how expected AOD and BRDF accuracy meet baseline requirements. New advanced possibility of aerosol and surface characterization with GRASP from combined AERONET plus S5p measurements will be discussed.

Liu, Xiaohong

Impacts of COVID-19 on Aerosol Direct and Indirect Radiative Forcing

Anthropogenic aerosols play an important role in the Earth's radiative budget. The unfortunate COVID-19 in 2020 has offered a rare opportunity to study the impacts of emission reductions of aerosols and precursors on the aerosol radiative forcing through interactions with atmospheric radiation and clouds. In this study, we use the NCAR Community Atmosphere Model version 6 (CAM6) with full chemistry (CAM6-chem) together with ground-based and satellite observations to investigate the COVID impacts on aerosol radiative forcing. CAM6-chem model treats nitrate aerosol based on the Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) and secondary organic aerosol (SOA) based on the volatility basic set (VBS) approach. We run the CAM6-chem for a period of January 2015 to June 2020 with observed sea surface temperature and sea ice. Two sets of ensemble simulations were conducted: one with the standard shared socioeconomic pathway (SSP245) emission scenarios for the whole time period and the other with reduced emissions for 2020 based on Forster et al. (2020). Differences in aerosol direct and indirect radiative forcing between the two sets of simulations for 2020 are identified and assessed for several major industrial regions (i.e., East Asia, India, U.S., Europe). Also, the differences in modeled aerosols (PM2.5, AOD, primary and secondary aerosols) between 2020 and climatologies of 2015 to 2019 are examined and compared to observations from ground-based and satellite observations.

Lord, Tobias

Investigation of the relative importance of meteorological and aerosol-related parameters in determining cloud microphysical properties using Machine Learning methods

Aerosols-cloud interactions and their effects on radiation are one of the main uncertainties in future climate projections. Not only because we are unsure of future changes in aerosol loading but also because the sensitivity to aerosol changes is uncertain. When studying aerosol-cloud interactions, often more or less simple versions of statistical analysis (or correlations) are performed and therefore it is often difficult to distinguish any potential signals from meteorological factors. Here, we present an alternative approach to studying this relationship through a Machine Learning perspective. Machine learning techniques on large sets of reanalysis and satellite data are used to investigate the relative importance of meteorological and aerosol-related parameters in determining cloud microphysical properties over different geografical regions. Specifically, a Gradient Boosting Regression model is trained to predict the Cloud Droplet Effective Radius supplied from the MODIS satellite record for each region. As input parameters to the model, we use meteorological parameters such as temperature, humidity, geopotential height and wind on 1000hPa, 850hPa and 700hPa from the ERA-5 Reanalysis dataset together with Aerosol Optical Depth from MODIS and SO_2 data from OMI. Preliminary results suggest that AOD has predictive power as expected from the decrease in droplet size following an increase in aerosol abundance. SO_2 does not seem to improve the model performance, although it has problems with data coverage. Therefore we also explore ways to deal with this poor data coverage in the satellite record. It is also shown that the model's predictions of the cloud droplet liquid radius are improved when given information about aerosols.

Luffarelli, Marta

Aerosol retrieval in presence of clouds

Several studies have shown that aerosol property retrieval from satellites is strongly affected by erroneous cloud identification or reflectance enhancement due to neighbouring clouds. In the vicinity of clouds, this enhancement leads to an overestimation of the retrieved aerosol optical thickness (AOT) and changes in the aerosol particle size. The choice of a cloud mask for aerosol property retrieval is thus critical as it might have a direct impact on the result. The ESA aerosol-cci project showed the effects of applying a common cloud mask to different aerosol retrieval algorithms as well as the impact of increasing the “safety zone” around clouds to reduce possible enhancement effects (Holzer-Popp et al., 2013). Similarly, in the merging exercise lead by Larissa Sogacheva (Sogacheva et al., 2020), where 16 monthly AOT products were combined, the cloud mask differences among these algorithms were identified as one of the major sources of discrepancies among the AOT products. To minimise these cloud contamination effects, the cloud mask in aerosol retrieval application is usually conservative, and the safety zone around clouds extends for few kilometers. For instance, in one of the aerosol-cci experiments, pixels within 10 km from clouds are discarded by the aerosol retrieval algorithms, resulting in a poor AOT spatial coverage. Cloud effects on aerosol retrieval become more important at higher resolution, e.g. 1km, where 3D effects can no longer be neglected. Over the past few years, efforts have been undertaken to reduce the high bias in AOT retrieval due to cloud enhancement while improving the aerosol spatial coverage. In 2017, Sogacheva et al. developed a cloud post-processing (CPP) method to remove residual clouds from aerosol optical depth. Applying the CPP to AATSR aerosol retrieval, the AOT spatial coverage increases by 10-15%. Nevertheless, the algorithm shows some limitation in discriminating high AOTs from cloud, especially for local aerosol events. A new method has been developed to address some cloud-related issues in aerosol retrieval. The CISAR algorithm (Govaerts and Luffarelli, 2018; Luffarelli and Govaerts, 2019) has been extended to the retrieval of cloud optical properties to overcome the need of an external cloud mask. After a so-called training period dedicated to the elaboration of a stable surface reflectance prior information, the CISAR algorithm process all available satellite observations, i.e. both cloudy and cloud free air. The new CISAR version, developed in the framework of the ESA SEOM CIRCAS project, has been applied to S3A/SLSTR observations aggregated at 5 km. Aerosols are retrieved in the vicinity of clouds as well as within optically thin clouds, assuring a larger spatial coverage than traditional aerosol retrieval algorithm. The new CISAR version also helps reducing the overestimation at low AOTs. The CISAR algorithm will be used in the framework of aerosol-cci+ to obtain a 1-year global product at 5 km from SLSTR observation.

Towards a consistent retrieval of cloud/aerosol single scattering properties and surface reflectance

The CISAR (Combined Inversion of Surface and AeRosols) algorithm is exploited in the framework of the ESA-SEOM CIRCAS (ConsIstent Retrieval of Cloud Aerosol Surface) project, aiming at providing a set of atmospheric (cloud and aerosol) and surface reflectance products derived from S3A/SLSTR observations using the same radiative transfer physics and assumptions. Traditionally, different approaches are exploited to retrieve the different Earth system components, which could lead to inconsistent data sets. The simultaneous retrieval of different atmospheric and surface variables over any type of surface (including bright surfaces and water bodies) with the same forward model and inversion scheme ensures the consistency among the retrieved Earth system components. Additionally, pixels located in the transition zone between pure clouds and pure aerosols are often discarded from both cloud and aerosol algorithms. However, this “twilight zone”, that can cover up to 30% of the globe, is of high interest to study the interactions between aerosols and clouds, which contribute the largest uncertainty to estimates and interpretations of the Earth’s changing energy budget. A consistent retrieval of both cloud and aerosol single scattering properties with the same algorithm could help filling this gap.
The CIRCAS project ultimately aims at overcoming the need of an external cloud mask, letting the CISAR algorithm discriminate between aerosol and cloud properties. This would also help reducing the overestimation of aerosol optical thickness in cloud contaminated pixels. CISAR is an advance algorithm developed by Rayference originally designed for the retrieval of aerosol single scattering properties and surface reflectance from both geostationary and polar orbiting satellite observations. The AOT retrieved with the current CISAR version, which does not rely on an external cloud mask, shows a correlation higher than 0.75 when compared with selected AERONET data. A more complete validation of the CISAR

retrieved, including surface reflectance, aerosol and cloud single scattering properties will be performed by Brockmann Consult. S3A/SLSTR images are processed with the CISAR algorithm at a 5 km resolution at Brockmann Consult in the Calvalus Processing System. The validation of the CISAR final product will be performed by comparison with ground observations (AERONET), other satellite retrievals (MODIS) and the S3 SYN product. This innovative version of the CISAR algorithm will be used in the framework of Aerosol-CCI+ to obtain a 1-year global product at 5 km from SLSTR observation.

Marbach, Thierry

EUMETSAT Aerosol Missions and Products: focus on 3MI, the Multi-View Polarimeter Flying on Metop-SGA

Aerosol composition and associated spatial distribution are key parameters for the improvement of the air quality and climate products. Therefore, EUMESAT will increase the number of satellite aerosol parameters provided operationally, which are driven by the 3MI instrument. The Multi-Viewing -Channel -Polarisation Imager (3MI) is planned to fly on the Metop-SGA satellites as part of the EUMETSAT Polar System - Second Generation (EPS-SG) program in the timeframe beyond 2022. It is a radiometer dedicated to aerosol and cloud characterisation for climate monitoring, atmospheric composition, air quality and numerical weather prediction. This polarimetric instrument is a heritage of the POLDER instruments, with improved capabilities. The spectral range (12 channels) was extended from the visible-near-infrared (410 to 910 nm) to the shortwave- infrared domain (up to 2200 nm). The spatial resolution (4 km at nadir) and the swath (2200 × 2200 km^2) were also improved compared to previous POLDER instruments. As POLDER, 3MI will provide multi-polarisation (-60°, 0°, and +60°), and multi-angular (10 to 14 views) images of the Earth top of atmosphere outgoing radiance **Error! Reference source not found.**. The level 1 products available to the users will be the geolocated Stokes vectors on the native geometry (Level 1B) and the geoprojected multi-directional and spectral Stokes vectors (Level 1C) **Error! Reference source not found.**. Level-2 products will provide geophysical and microphysical parameters for aerosols and clouds. The presentation will overview EUMETSAT current and future aerosol missions and products with focus on the aerosol retrieval for the 3MI operational product using the GRASP algorithm **Error! Reference source not found.**. The retrieval provides extended set of aerosol and reflectance surface parameters. The performance of the algorithm prototype will be illustrated using synthetic proxy, as well as, real POLDER/PARASOL data.

McQueen, Jeff

Overview of NOAA's global aerosol modeling progress

The NEMS coupled app (GFS-CHEM) includes two components: The NCEP Global Forecast System (GFS V15) and GSDCHEM. GSDCHEM is a National Unified Operational Prediction Capability (NUOPC) based chemistry component developed to replace the current NEMS GFS Aerosol Component (NGAC at 1x1°, Bhattacharjee et al., 2018; Wang, et al. 2018) GSDCHEM includes the WRF-Chem (Grell, et al. 2005) chem_driver with updates for consistency with the NASA Goddard Operational Chemistry and Aerosol Radiation and Transport (GOCART; Chin, et al., 2007) version. The chemistry and aerosol modules used for GFS-CHEM include simple sulfur chemistry, hydrophobic and hydrophilic black and organic carbon, and a 5-bin sea salt module. Additionally, included is the FENGSHA (Dong, et al. 2016) 5-bin dust module, wildfires modeling using Fire Radiative Power (FRP) and smoke emissions from the NESDIS Global Biomass Burning Emissions Product (GBBEPx; Zhang, et al., 2014; Zhang, et al., 2012). Plume rise modeling is done with a 1-d cloud model (Grell & Freitas, 2014), and, optionally, volcanic ash emissions are also included. The global anthropogenic emission is from the Community Emissions Data System (CEDS) based on 2014 inventory. Tracers are transported by the dynamics as well as the GFS physics (GFS PBL and Simple Arakawa Schubert (SAS) deep and shallow convection parameterization). Subgrid scale wet scavenging and transport is done inside the two SAS routines. The system runs on the FV3 cube sphere C384L64 resolution (~25 km) in the NCEP Global Ensemble Forecast System (GEFS) production suite, but with GOCART simple aerosol chemistry (20 species) run to 120 forecast hours four times per day. GFS-Chem currently requires 40 nodes to run 5 days in 37 cpu minutes on the Dell Phase III systems. Technically, coupling occurs two-way, as mixing ratios of chemical tracers are exchanged between FV3GFS and GSDCHEM at each coupling step to be advected by FV3 dynamical core. However, at this point coupling is considered to be only one way in this milestone from a scientific standpoint, since feedback to the meteorology is not yet activated. This presentation summarizes the new operational, global aerosol capability at NOAA with a general overview of performance for 2019.

Mielonen, Tero

Comparing aerosol types in climate models and satellite retrievals

Identification of aerosol types (in terms of their source origin and main composition) is important because of the effects that different aerosols have on health, visibility and Earth's climate. When aerosol types are known, their sources can be identified more precisely and required actions can be better targeted. However, typing of the atmospheric aerosols using satellite retrieved aerosol properties is a challenging endeavor due to uncertainties associated with the retrieval process and top-of-atmosphere measurements. Furthermore, the comparison of simulated and retrieved aerosol types is difficult as models tend to categorize aerosols based on their chemical composition whereas the types used in satellite retrievals are more tightly linked to their sources. To overcome this hurdle between models and observations we present a simple method which enables direct comparison between simulated and observed aerosol types. In this work we have applied a set of robust thresholds for the typing mainly concentrating on the size distribution and optical properties of aerosols. The Ångström exponent and single scattering albedo (SSA) were used as proxies for these properties, respectively. The retrieved aerosol optical depth (AOD) was used as an auxiliary parameter supporting the other parameter thresholds to single out on one hand background aerosol conditions (low AOD), and on the other hand high aerosol concentration conditions (anthropogenic pollution, dust outbreaks). Then we calculated the frequency of different aerosol types globally and in several subregions. By comparing the regional distributions of these aerosol types we can see where and for which aerosol types the simulations and retrievals are in agreement and where they disagree the most. This information is essential for bridging the gap between observed and simulated aerosol types and, hopefully, it will help the satellite and model communities find a common language regarding this topic. We present here results of the typing when the aerosol retrievals have been done with data from the Sea and Land Surface Temperature Radiometer (SLSTR). The employed aerosol retrieval algorithm provides an aerosol model via a set of mixing ratios of aerosol components as a result. The ratios can then be used to determine any desired aerosol property, thus enabling the aerosol typing described above. The retrieved aerosol types were compared with the simulation results available from the Aerocom CTRL2016-experiment. The models

included in the analysis were: ECHAM6-HAM, ECHAM6-SALSA, ECMWF-IFS, HadGEM3 and SPRINTARS. Our preliminary results show that there are significant differences between the retrieved and simulated frequencies of aerosol types regionally and globally. The best agreement was found for dust, sea salt and biomass burning aerosols but the agreement was still modest.

Mortier, Augustin

Evaluation of climate model aerosol trends with ground-based observations over the last two decades – an AeroCom and CMIP6 analysis

We present the results of the study "Evaluation of climate model aerosol trends with ground-based observations over the last two decades - an AeroCom and CMIP 6 analysis" currently under revision in the ACP journal. In this work, the aerosol trends are consistently investigated in the different regions of the world using a set of 9 optical, microphysical and chemical parameters coming from sun photometers and in situ measurements. These observed trends, which are shown to be more or less representative depending on the networks coverage, are used as a reference database for the validation of the trends computed with a subset of models taking part in the historical experiments of AeroCom phase III and CMIP6. The models tend to capture observed AOD, AE, SO4 and PM trends but show larger discrepancies regarding AOD>1µm. The smaller amount of data available for establishing σsp and σap trends to make the validation of the modeled trends more uncertain. The global trends computed using model data give a different picture than the trends obtained when using only ground-based observations due to the partial coverage of the measurements. Finally, we present an additional preliminary analysis of the trends computed with all of the CMIP6 models by focusing on the AOD parameter.

COVID-19: Impact on AOD and European Air Quality

The unprecedented measures taken in 2020 aiming to minimize the spread of the COVID-19 had a very strong impact on the economic activity, and thus on anthropogenic emissions of air pollutants. With this poster, we propose a preliminary analysis of the Aeronet AOD deviation in 2020 through a selection of results extracted from a dedicated web-page (https://aerocom-trends.met.no/covid-19.php). In June 2020, about 75% of the countries equipped with sun photometers depict negative AOD deviations as compared to earlier years. An overview of the CAMS - policy support activities focusing on the COVID impact on air quality in Europe and using regional models, which shows more complex results when focusing only at the ground level, will also be discussed.

Myhre, Gunnar

Update on AeroCom Historical experiment

Nabat, Pierre

Evaluation of aerosol absorption in CMIP6 simulations

In this presentation, aerosol absorption properties (single scattering albedo, absorption aerosol optical depth) from different CMIP6 historical simulations will be evaluated over the recent years (1995-2014) through comparisons to available observations. We will use notably measurements from the AERONET network, as well as satellite products such as GRASP-POLDER and OMI data. The MACv2 dataset (Kinne, 2019) will also be used to complete the analysis. First results show a large range in the CMIP6 simulations, with possible impacts on radiation.

Neubauer, David

Soot aging by ozone/sulfuric acid enhances future warming and reduces shortwave aerosol cooling by changing cloud formation

Previous laboratory studies found no effect of soot aging by ozone oxidation on the cloud condensation nuclei (CCN) activity of soot particles. These studies were typically conducted at very high ozone concentrations and for short aging times. Recent laboratory studies at ambient ozone concentrations and temperatures and for aging times of up to 12 hours, mimicking realistic aging conditions of soot particles in the atmosphere, however found a significant increase in the CCN activity of soot particles. Further recent experimental studies found that processing of soot particles in mixed-phase or cirrus clouds or in aqueous sulfuric acid solutions enhances the ice nucleating ability of soot particles at temperatures colder -40 °C. Implementing these findings into the global aerosol-climate model ECHAM6.3-HAM2.3 we find a reduction in shortwave aerosol forcing by 0.2 to 0.3 Wm-2, dominated by changes in cloud formation. The equilibrium climate sensitivity (increase in surface temperature by doubling of CO2) increases by 0.4 to 0.5 K when accounting for these soot aging processes. Reducing soot emissions will therefore be beneficial for future climate.

Pagowski, Mariusz

Development of the National Global Data Assimilation Ensemble-based System for Forecasting of Aerosols at NOAA

Recently, NOAA embarked on a major redesign of its environmental prediction system that includes a new dynamical core of a numerical model and a new data assimilation system. The dynamical core is based on FV3 model from NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) while data assimilation development relies on the Joint Effort for Data assimilation Integration (JEDI) framework that is being developed nearly from scratch with a paradigm of flexibility based on object oriented design of computer codes. The chemical model under development couples FV3 meteorology with Goddard Global Ozone Chemistry Aerosol Radiation and Transport (GOCART) aerosol parameterization. Assimilation relies on a hybrid variational/Ensemble Kalman Filter (EnKF) methodology with stochastic perturbations to meteorology and emissions. Observations include retrievals of Aerosol Optical Depth

(AOD) derived from Visible Infrared Imaging Radiometer Suite (VIIRS). Results are evaluated against AErosol RObotic NETwork (AERONET) and Copernicus Atmosphere Monitoring Service interim Reanalysis (CAMSiRA) and Modern-Era Retrospective analysis for Research and Applications (MERRA-2).

Pan, Xiaohua

Update on AeroCom Biomass Burning Emission Injection Height experiment (BBEIH)

The environmental impact of smoke aerosols depends not only on the emitted mass, but also on the injection height. This is especially true for large boreal forest fires that often emit smoke above planetary boundary layer (PBL) into the free troposphere and even the lower stratosphere. However, most atmospheric chemistry transport models (CTMs) assume that fire emissions are dispersed only within PBL, or use simple plume-rise parameterizations. In order to test the sensitivity of model results to biomass burning smoke injection height, we proposed the biomass burning emission injection height experiment (BBEIH) in the AeroCom 2019 workshop. The description of implementation methods and input data for BBEIH can be found in https://wiki.met.no/aerocom/phase3-experiments#biomass_burning_emission_injection_height_experiment_bbeih. In BBEIH, we introduced the biomass burning injection heights based on MISR stereo-derived plume-height retrievals (Val Martin et al., 2010; 2018) in four participating CTMS. Specifically, we proposed 4 runs:

- (1) BASE: using the biomass burning emissions from Global Fire Emissions Database version 4 with small fires (GFED4s) and the model default fire emission injection height;
- (2) BBIH: Same as BASE, but using the injection height derived from the seasonal-regional varying MISR-retrieved plume heights;
- (3) NOBB: no fire emission;
- (4) Same as BASE, but using Fire Energetics and Emissions Research version 1.0 (FEER 1.0).

We will address the following scientific questions: 1) To what extent are the model simulations sensitive to the assumed biomass burning injection height? 2) In which regions/seasons/surface-types are the aforementioned sensitivities most important? We will focus on near-source characteristics and downwind plume evolution of vertical aerosol distribution and aerosol optical depth (AOD) from the four participating CTMS in this year’s update.

Piontek, Dennis

Recent Advances in Satellite Retrieval of Volcanic Ash Properties

Artificial neural networks (ANNs) have been successfully applied to various remote sensing problems. Here we use ANNs to detect and analyze volcanic ash clouds in MSG-SEVIRI images and use radiative transfer calculations based on realistic ash properties to train the ANN. We present novel investigations of the different steps considered for these radiative transfer calculations. First, we tackle the question of the complex refractive index (RI) of volcanic ash. While it can vary strongly between different eruptions, some models use a limited set of RI measurements Here we sketch a method to calculate the RI of volcanic ashes for wavelengths from 5 to 15µm from measurements of their individual components (i.e. minerals, glasses, gas bubbles) based on generic petrological ash compositions. Thereby the refractive indices for volcanic glasses and bulk volcanic ashes of different chemical compositions are derived. Second, we address the impact of macrophysical volcanic ash plume properties (i.e. mass loading, cloud top height, vertical mass profile, multiple layering) on corresponding MSG-SEVIRI observations. Whereas the exact vertical profile is negligible, multiple layers can distort the brightness temperatures by about 0.5 K or more. Cloud top height and mass loading have the largest impact; the latter is retrievable up to roughly 30 g/m² with MSG-SEVIRI. Based on these findings, we calculate the training samples using the radiative transfer model libRadtran. These are used to train different ANNs with specific tasks (e.g. retrieval of optical depth, plume top height, effective radius). The performance of these algorithms is quantified with respect to an independent simulated test data set. This allows us to systematically investigate strengths and weaknesses of the retrievals with respect to plume properties (e.g. optical thickness), geographic and meteorological conditions. Finally, we compare our retrievals with in-situ and lidar measurements for the eruptions of Eyjafjallajökull (2010) and Puyehue-Cordón Caulle (2011).

Povey, Adam

Making the old new again: Overhauling ORAC

The Optimal Retrieval of Aerosol and Cloud (ORAC) is an open-source retrieval of aerosol and cloud properties from visible and infrared satellite imagery, supporting AVHRR, ATSR, MODIS, SEVIRI, SLSTR, Himawari, and more. In applying the algorithm to new parts of the spectrum and more diverse orbital geometries, some "issues" have come to light. This poster will outline my work in the time of COVID, testing assumptions in our retrieval and implementing a new formulation of surface reflectance.

Puthukkudy, Anin

Aerosol properties from Airborne Hyper Angular Rainbow Polarimeter (AirHARP) observations during ACEPOL 2017

Multi-angle polarimeters (MAP) imaging has the potential to retrieve aerosol optical and micro-physical properties. In this work, we report the demonstration of capabilities of a wide swath MAP instrument called Airborne Hyper Angular Rainbow Polarimeter (AirHARP) which is an aircraft version of HARP CubeSat. AirHARP is a novel instrument developed at Earth and Space Institute (ESI) in the University of Maryland Baltimore County to measure Stokes parameters I, Q, U in four spectral bands. It features hyper-angular imaging capability with 60 viewing angles at 670 nm and 20 viewing angles at 440, 550, and 870 nm across the full 114° (94°) along-track (cross-track) field-of-view. AirHARP collected several data on the multi-angle radiance and polarized radiance information of the Earth's atmosphere and surface during the NASA ACEPOL campaign in 2017. Aerosol information like aerosol optical depth, single scattering albedo, complex refractive index, particle size distribution, and information on the shape of the particle are retrieved from the AirHARP observations using an inversion algorithm called GRASP. Since the aerosol retrievals are an ill-conditioned problem, the retrieved products should be used with caution and must be validated with direct measurements wherever it is possible. Indirect measurement of aerosol optical depth from the AirHARP is compared and validated with direct measurements from sun photometer (AERONET). Results show that the AirHARP aerosol optical depth has a good correlation with direct measurements. Complex refractive index and single scattering albedo

of a forest fire smoke plume have been retrieved from the AirHARP observations using GRASP and the values are within the range observed during several laboratory measurements of biomass burning aerosols. Finer particles with a volume median radius of 0.157 um and a standard deviation of 0.55 um for fine mode is observed for the same smoke plume. These results serve as a proxy for the scale and detail of aerosol retrievals that are anticipated from future space mission data, as HARP CubeSat and HARP2 (aboard the NASA PACE mission with the launch in 2023) are near duplicates of AirHARP and are expected to provide the same level of aerosol characterization.

Quaas, Johannes

Assessing aviation-induced cirrus from satellite during COVID-19

Air traffic was reduced by 70% in large regions in boreal spring 2020 compared to 2019. We used this opportunity to analyse cirrus from MODIS data in comparison to weather analogues in the past (2011 - 2019) to see that cirrus in 2020 was reduced by a significant fraction. The implied radiative forcing is computed.

Righi, Mattia

Coupling aerosols to (cirrus) clouds in a global aerosol-climate model

The impact of aerosol on atmospheric composition and climate still represents one of the largest uncertainties in the quantification of anthropogenic climate change. This is particularly the case for modelling aerosol-cloud interactions, which requires a detailed knowledge of various processes acting on a wide range of spatial and temporal scales. While significant progress has been made in developing parameterizations for describing the aerosol activation process in liquid clouds in the framework of global models, the aerosol-induced formation of ice crystals in cirrus clouds is still poorly understood and only a few global models include explicit representations of aerosol-cloud interactions in the ice phase. This is due to the high complexity of the freezing processes occurring in the ice phase, the uncertain properties of ice nucleating particles, and the competition between homogeneous and heterogeneous freezing at cirrus conditions. To tackle this issue, this study documents the implementation of a new cloud microphysical scheme, including a detailed parameterization for aerosol-driven ice formation in cirrus clouds, in the global chemistry climate model EMAC, coupled to the aerosol submodel MADE3. The new scheme is able to consistently simulate three regimes of stratiform clouds (liquid, mixed- and ice-phase/cirrus clouds), considering the activation of aerosol particles to form cloud droplets and the nucleation of ice crystals. In the cirrus regime, it allows for the competition between homogeneous and heterogeneous freezing for the available supersaturated water vapor, taking into account different types of ice-nucleating particles, whose specific ice-nucleating properties can be flexibly varied in the model setup. The new model configuration is tuned to find the optimal set of parameters that minimizes the model deviations with respect to observations. A detailed evaluation is performed comparing the model results for standard cloud and radiation variables with a comprehensive set of observations from satellite retrievals and in-situ measurements. The performance of EMAC-MADE3 in this new coupled configuration is in line with similar global coupled models and with other global aerosol models featuring ice cloud parameterizations. Some remaining discrepancies, namely a high positive bias in liquid water path in the northern hemisphere and overestimated (underestimated) cloud droplet number concentrations over the tropical oceans (in the extra-tropical regions), which are both a common problem of this kind of models, need to be taken into account in future applications of the model. To further demonstrate the readiness of the new model system for application studies, an estimate of the anthropogenic aerosol effective radiative forcing (ERF) is provided, showing that EMAC-MADE3 simulates a relatively strong aerosol-induced cooling, but within the range reported in the IPCC AR5 and in other, more recent, assessments.

Robbins, Daniel

Identifying cloud and aerosols during extreme bushfires using deep learning

In December January of 2019/2020, Bushfires blanketed the Australian capital cities with smoke causing major air quality issues. Thick plumes of smoke were observed to circulate the southern oceans for many weeks. Smoke plumes are often so thick they are misclassified as clouds in current cloud identification algorithms. Accurate identification of smoke plumes is necessary to provide information on plume injection height and aerosol extent to evaluate climate models and assimilate into air quality models. Recent advancements in passive imagers for geostationary satellites, such as the AHI instrument onboard Himawari-8, has significantly increased the spatial and temporal resolution with which bushfires can be tracked and observed in Australia. We present progress towards a machine learning approach to identifying cloud and aerosol from geostationary satellite data using the Australian bush fires as a case study. In this poster we present a new data set of AHI measurements collocated with CALIOP for the purpose of training a set of neural networks and initial first results of neural net algorithm to identify cloud and aerosol.

Ryder, Claire

Aircraft observations of Coarse Dust: Radiative Significance and Model Evaluation

Many impacts of mineral dust on climate are sensitive to dust particle size distribution (PSD), yet models struggle or even fail to represent coarse (diameter (d) >2.5 µm) and giant (d>20 µm) dust particles and the evolution of the PSD with transport. Here we examine three state-of-the-art airborne observational datasets, all of which measured the full size range of dust (d=0.1 to >100 µm) at different stages during transport, with consistent instrumentation. We quantify the presence and evolution of coarse and giant particles and their contribution to optical properties using airborne observations over the Sahara (from the Fennec field campaign) and in the Saharan Air Layer (SAL) over the tropical eastern Atlantic (from the AER-D field campaign) as described in Ryder et al. (2019). Observations show effective diameters of up to 20 µm over the Sahara, compared to 4 µm in the SAL. Excluding giant particles over the Sahara results in significant underestimation of mass concentration (27%), as well as underestimates of both shortwave and longwave extinction (18 and 26% respectively from scattering calculations). The larger impact on longwave extinction compared to shortwave implies a bias towards a radiative cooling effect in dust models, which typically exclude giant particles and underestimate coarse mode concentrations. Airborne in-situ vertically resolved, size-resolved dust mass concentration observations provide a unique opportunity to evaluate model dust transport of the full size spectrum, covering fine, coarse and giant dust particles and offer an insight into any deficiencies in modelled dust transport from the Sahara. We apply the airborne SAL in-situ observations as well as airborne elastic backscatter lidar, as well as observations from Cloud-Aerosol Transport System spaceborne lidar (CATS) and the Moderate Resolution Imaging Spectroradiometer (MODIS) to investigate the dust forecasts from two operational global atmospheric models (the Met Office Unified Model (MetUM) and the Copernicus Atmosphere Monitoring Service (CAMS)) during August 2015, as described in O'Sullivan et al. (2020). The models were found to place dust too low in the atmosphere compared to observations. Both models were found to underpredict coarse dust, and at times overpredict fine mode dust. Dust AODs from the models agreed well with observations, albeit with a low bias. It was found that since the models are fine-tuned to represent the observed optical depth, the fine mode is set to compensate for the underestimation of the coarse mode. The bias in modelled size distribution and dust plume altitude has implications for radiative effects and long-range dust transport. A compilation of published effective dust size as a function of dust age since uplift time suggests that two regimes of dust transport exist. During the initial 1.5 days, both coarse and giant particles are rapidly deposited. During the subsequent 1.5 to 10 days, PSD barely changes with transport, and the coarse mode is retained to a much greater degree than expected from estimates of gravitational sedimentation alone. The reasons for this are unclear, and warrant further investigation in order to improve dust transport schemes, and the associated radiative effects of coarse and giant particles in models.

Samset, Bjorn

Aerosol absorption in CMIP6 and its implications for projected precipitation changes under the Shared Socioeconomic Pathways

Aerosol absorption, quantified through Absorption Aerosol Optical Depth (AAOD), is poorly constrained in both models and observations. Further, shortwave absorption is known to inhibit precipitation formation through rapid adjustments, affecting cloud formation, the atmospheric temperature lapse rate, and the local energy budget. I document the AAOD reported by CMIP6 models, over the historical era end following a key set of SSP emission scenarios. The intermodel spread is striking, both in absolute values and in anomalies relative to 1850-1900. Then, I link the AAOD anomalies to shortwave absorption, and from there to precipitation change, documenting a potentially large contribution to the remaining precipitation diversity in CMIP6 projections from this source alone. This result underpins the need for improved quantification of aerosol absorption, notably in regions of rapidly changing emissions such as Southern and Eastern Asia.

Sayer, Andrew

How consistent are satellite retrievals of smoke from the 2019-2020 Australian fires?

The summer 2020 Australian fire season resulted in several large-scale smoke plumes transported across the continent and southern Pacific Ocean between September 2019 and February 2020. Satellite retrievals of quantities such as aerosol optical depth (AOD) are used widely to constrain and evaluate

climate models. However these retrievals are challenged by extreme events, where retrieval assumptions may be violated, and observability issues affect their representation in data aggregates (e.g. monthly means). We compare satellite sampling and retrievals of AOD (as well as retrieved or implied absorption AOD) during this fire season. We recognize that extreme events are inherently difficult for retrievals because they are an out-of-family event, but at the same time assumptions applied in large-scale data processing remain necessary due to the limited information content of current satellite sensors. We hope to open a discussion within our community on (1) practical steps to improving the representation of extreme events within available satellite record, and (2) potential new future measurement/retrieval strategies to improve the quantification of absorbing aerosols, and their vertical profiles, from space. This presentation presents the fires as a case study to illustrate the current state of the science, and links with a separate presentation by us (A. M. Sayer, V. Natraj, F. C. Seidel) on absorbing aerosols also submitted to this workshop.

Schutgens, Nick

An AEROCOM/AEROSAT study: evaluation of global models with satellite AAOD and SSA

This presentation summarizes two papers close to submission: the first one on the evaluation of satellite products, the second one on the evaluation of models with said satellite products. Several satellite products (POLDER-GRASP, PLDER-SRON, OMAERUV and FL-MOC) of AAOD and SSA are evaluated with AERONET and intercompared. Although these products correlate rather well with AERONET observations, the paucity of collocated AERONET observations make it difficult to evaluate product performance by region. This introduces a 'blind spot' in our understanding of satellite AAOD that we alleviate with satellite product intercomparisons. This intercomparison reveals that satellite biases may be signifcantly larger than an AERONET evaluation suggests. In particular we see a global difference of 0.04 between two POLDER SSA products, which is reduced to 0.02 when considering an AERONET evaluation. Interestingly, this bias is fairly independent of AOD and region, so identifying its cause might drastically improve agreement between two major satellite SSA products. Tentatively, we suggest that cloud contamination is part of the reason of this bias. Irrespective of such bias, we show that minimum AOD thresholds and temporal averaging of data improves agreement between satellite datasets. At the least, this suggests convergence of different datasets based on either POLDER, OMI or CALIOP measurements. We then use these satellite datasets to evaluate AEROCOM models (CTRL runs from Phase-II, Phase-III-2016 and Phase-III-2019). We begin by showing that although satellite products show systematic biases vs each other, they nevertheless provide similar evaluation results for individual models. This includes model evaluation with AERONET data (if available). We show that this can be achieved through suitable transformations (e.g. considering the ratio of model and observed AAOD, instead of differences). We introduce a new graphical plot for the evaluation of model AAOD and SSA, that takes into account both observational errors and representation errors. The analysis shows that several Phase-III models globally underestimate AAOD and overestimate SSA while other models over-estimate AAOD and underestimate SSA in biomass burning regions. This is different from the situation with Phase II models, when almost all models globally underestimated AAOD and overestimated SSA. On the whole, model diversity in AAOD has increased from Phase II to III. From Phase-III-2016 to 2019, there is a small decrease in model diversity. Finally, we show that for the Phase-III models, diversity in black carbon and dust emissions seems the most important cause of AAOD diversity. As a matter of fact, across the AEROCOM ensemble, there is an almost linear relationship between black carbon emission and AAOD, at least over source regions. This allows us to estimate black carbon emissions from satellite data using the AEROCOM ensemble as a constraint.

Seidel, Felix

"Beyond AOD", a team science initiative to quantify vertically resolved aerosol absorption to enable climate science breakthroughs

Substantial investments and efforts by the international research community enabled global observations of Aerosol Optical Depth (AOD) such that it has improved our understanding of climate and air quality, as well as our ability to predict change. We now have a new opportunity in front of us — with the upcoming next-generation of aerosol observing missions, such as EarthCARE, PACE, EPS-SG, Sentinel-5, and ACCP — to start focusing efforts on aerosol remote sensing "beyond AOD".
We argue that the next major breakthrough in the "Beyond AOD" initiative will be provided by the quantification of absorbing aerosol and their vertical profiles, because 1) aerosol absorption is connected to direct and indirect radiative forcing, atmospheric dynamics, cloud formation, aerosol processing, etc., which together make aerosol absorption key to better constrain the aerosol climate sensitivity and 2) the next generation of satellite measurements should make it feasible to provide the necessary quantification over the upcoming decade. Resolving aerosol absorption is important because the ability to answer some of the most profound climate science questions will depend on improved process understanding and quantitative observations; we cannot afford to wait decades to make this breakthrough. AeroSAT brings together the aerosol remote sensing community, providing an ideal avenue to start discussions on "Beyond AOD". It will require a team science initiative to make progress towards the stated goal. This is a great opportunity to discuss potential ways forward for the initiative. The "Beyond AOD" initiative is closely related to a separate presentation by the authors on the current state of the art (and its limitations) for the operational retrieval of aerosol absorption during extreme events using the recent Australian fires as a case study.

Skeie, Ragnhild

Changes in aerosol atmospheric composition and radiative forcing due to COVID-19 in OsloCTM3

Recently aerosol precursor emissions are declining worldwide due to containment policies to combat the COVID-19 pandemic. An emission inventory for these emission reductions in 2020, and assumptions for further emission development, are used as input to a chemical transport model (OsloCTM3), and atmospheric aerosol composition changes relative to a baseline emission scenario (SSP2-4.5) are modeled. Further, aerosol radiative forcing for these changes are calculated. The focus year is 2020, but aerosol forcing timeseries are also presented for the different recovery scenarios (fossil fuel, moderate green and strong green) that are developed.

Smith, Steven

Emissions-MIP: A Multi-Model Sensitivity Evaluation

Modeling historical and future atmospheric conditions depends on both well-characterized estimates of aerosol, precursor and reactive gas emissions and accurate models. The Emissions-MIP project aims to determine how a number aerosol and precursor emissions impact model results including: effective injection height, seasonality, sub-grid sulfate assumptions, and the spatial distribution of shipping emissions. 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 or how models might respond differently to these assumptions. Differences in modeling assumptions for these aspects could also contribute to unquantified inter-model differences. In phase 1 we focus on atmosphere-only simulations from multiple modeling groups, including CTMs, covering a range of sensitivity cases. This poster will summarize the phase 1 experimental protocol and present preliminary results. Differences in the sensitivity to these perturbations between models is also of interest as this indicates potential areas where additional model and/or data development may be needed. Phase 2 of the project in calendar year 2021 will compare coupled model simulations for selected phase 1 cases where model sensitivity was found to be particularly high.

Sogacheva, Larisa

Comparisons of multi-spectral satellite AOD

Satellite retrieved Aerosol Optical Depth at 550 nm (AOD_{550}) and Angström exponent are the main aerosol characteristics used in the aerosol modelling community. AOD_{550} product, often provided with uncertainties, is in general of good quality, which is confirmed through the validation with AERONET. Quality of the AE, which if provided without estimated uncertainties, is much lower. The main reason for that is that the uncertainties in AOD at each of the wavelengths used are compounded in AE calculations. Miss-interpretation of the AE, in turn, leads to wrong assumptions on particle size and type. Discussions were raised during the AEROSAT-2019 meeting on whether satellites can independently measure the spectral AOD at different wavelengths. When trying to make progress on retrieved aerosol properties, Ralph Kahn made the initial suggestion about using retrieved spectral optical depth at multiple wavelengths rather than AE as an indicator of additional information about aerosol properties beyond mid-visible AOD. Thus, the AEROSAT team initiated an exercise to study multi-spectral AOD. In this exercise, we are planning to collect the information on the “initial” (e.g., AOD at available wavelengths) and/or “derived” (e.g., AE, AOD_{550} if calculated using AE) products retrieved from different satellites and different approaches and perform validation/evaluation of the products when validation databases are available. The outcome of the exercise will be recommendations for modelling community on the usage of the satellite products with providing corresponding validation results. Besides AOD and AE, information on other aerosol properties, such as fine mode fraction, which generally represents an interpretation of spectral optical depths, particle size distribution, shape, complex refractive index, which are available and can be utilized in the models, will be collected and, when possible, evaluated. First steps – ATBDs reviews, data collection - done in the frame of that exercise will be presented; further activity will be discussed.

Song, Quianqian

Comparison Study of Global Dust Climatology derived from CALIOP and MODIS Aerosol retrievals

In this study, we derive and compare two decadal (2007-2016) and global dust climatology datasets derived from the satellite observations. Both datasets contain the horizontal distribution of dust optical depth (DAOD) on a global scale. One is based mainly on CALIOP observations that distinguish dust from other types of aerosols using lidar depolarization signal caused by the irregular nonspherical shape of dust. The other is based on MODIS observations that detect dust aerosols using their relatively large size in comparison with other types of aerosols. The comparison reveals that MODIS DAOD is generally larger than CALIOP DAOD. The CALIOP-based DAOD is in good correlation with MODIS-based DAOD over the Sahara Desert and Atlantic Ocean although on average, CALIOP DAOD is 26%~30% smaller. However, the correlation is poor for Asian dust and dust over Northwest Pacific Ocean (NWP). Despite the discrepancy in the magnitude of DAOD derived from two sensors, both sensors show very similar annual variability in DAOD. For dust aerosol over NWP, both MODIS and CALIOP show a declining trend with a decreasing rate of -1.5% yr-1 based on MODIS retrieval and -2% yr-1 based on CALIOP retrieval. This annual decreasing trend was likely attributed to a decreasing trend of -2.6% in spring (MAM) from MODIS retrieval and -2.8% in spring (MAM) from CALIOP retrieval but negligible trends in the other seasons. Furthermore, we found the decreasing trend of dust over NWP is potentially due to the decline of dust aerosol generated from Gobi Desert with an annual decreasing rate of -2.3% based on CALIOP and -3.5% based on MODIS. Moreover, DAOD trend will be analyzed in other dust sources and dust outflow regions.

Su, Wenying

Understanding the top-of-atmosphere fluxes difference between AeroCom Phase III models and the CERES product: clear-sky perspective

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). The CERES Energy Balanced and Filled (EBAF) product includes monthly mean shortwave (SW), longwave (LW), and net TOA all-sky and clear-sky radiative fluxes over 1-degree latitude by 1-degree longitude regions. The EBAF SW and LW fluxes are adjusted within their uncertainties to be consistent with the heat storage in the Earth-atmosphere system (Johnson et al. 2016). EBAF also provides a gap-free monthly mean clear-sky flux map by inferring clear-sky fluxes from both CERES and MODIS measurements (Loeb et al. 2018). In this study, we compare the TOA clear-sky fluxes from Aerocom phase III output with those from the CERES EBAF products. Flux differences over the ocean are generally smaller than over the land, and the magnitude of the differences shows seasonal and regional dependency. To understand the flux differences, aerosol optical depths (AOD) from the Aerocom models are compared with the satellite retrievals from MODIS and MISR. Over the ocean, the AOD differences and the flux differences show consistent regional features, indicating that the differences between models and observations are robust as the CERES EBAF clear-sky SW fluxes and MODIS/MISR AODs are determined independently. However, very little resemblance is found between the AOD and flux differences over the land. To further understand the cause of the flux differences over the land, we compare the land surface albedo from MODIS with the albedo from the models and find consistency in regional albedo differences and flux differences. Monthly regional radiative kernels of AOD and surface albedo derived using the MERRA-2 reanalysis data (Thorsen et al. 2020) are applied to AOD and surface albedo differences between models and observations. For most of the models, the AOD and surface albedo differences can explain most of the flux differences between models and CERES EBAF. The EOS era satellites have provided 20 years of carefully calibrated and validated observations that are suitable for trend analysis. Both the MODIS AOD and CERES EBAF clear-sky SW flux show decreasing trends over the coastal regions of eastern China and the eastern United States due to the emission control policies enforced in both countries, and an increasing trend off the coast of India. The AOD and clear-sky SW flux trends are less consistent over land, as the surface albedo changes complicate the clear-sky SW flux trend. The AOD and clear-sky SW flux trends from the Oslo model HIST run are also examined. However, none of the aforementioned regional trends are found in the model results.

Comparison of the trend derived from AeroCom historical experiment with the satellite observations

The EOS era satellites have provided 20 years of carefully calibrated and validated observations that are suitable for trend analysis. Both the MODIS AOD and CERES EBAF clear-sky SW flux show decreasing trends over the coastal regions of eastern China and the eastern United States due to the emission control policies enforced in both countries, and an increasing trend off the coast of India. The AOD and clear-sky SW flux trends are less consistent over land, as the surface albedo changes complicate the clear-sky SW flux trend. The AOD and clear-sky SW flux trends from the Oslo model HIST run are also examined. However, none of the aforementioned regional trends are found in the model results.

Tackett, Jason

CALIOP Aerosol Typing Performance of Smoke from the 2019-2020 Australian Bushfire Event

A series of pyroCb events occurred in southeast Australia in late December 2019 and early January 2020 injected a large amount of smoke into the stratosphere. CALIOP observations provided critical measurements of the plume in the stratosphere which gave clues about its microphysical properties. An upcoming revised version of the CALIOP level 2 data products will feature improved aerosol typing in the stratosphere. Above the tropopause, the level 2 products discriminate between smoke, volcanic ash, and volcanic sulfate. Accuracy of aerosol typing is critical for automated surveys characterizing distributions of anthropogenic versus natural aerosol and is essential for accurate aerosol extinction retrievals from elastic backscatter lidars such as CALIOP. This poster will describe the aerosol typing algorithm, highlight upcoming improvements, and assess the performance of the CALIOP aerosol typing algorithm for the Australian bushfire event.

Thompson, Sabrina

Analysis of Scattering Angle Sampling by Multi-Angle Imaging Polarimeters for Different Orbit Geometries

Per the 2017-2027 Decadal Survey for Earth Science and Applications from Space, many resources are being dedicated to identifying the most cost-effective and appropriate space-based approaches to aid in answering important questions related to the roles of Aerosols and Clouds, Convection, and Precipitation (A-CCP) within the climate system. This includes the push for developing advanced space-based polarimetric imagers for monitoring aerosols and clouds. Currently, multi-angular, multi-spectral polarimeters, such as SPEXOne and HARP2 have been developed for the upcoming NASA PACE mission. Together, these polarimeters will be used to advance our understanding of aerosols, clouds and their interactions. The information content of such instruments partly depends on the range of scattering angles that they sample. For example, polarimetric retrievals of cloud droplet size distributions require observations of the primary and supernumerary cloud bow within a scattering angle range of about 135° and 165°. Factors influencing the sampled scattering angle range include orbit geometry, solar and viewing angle geometry, day of year (DOY), angular resolution, and other factors. The focus of this research is to gain better insight about how each of these factors influence scattering angle range for different polarimeter platforms, including SPEXOne, HARP2, as well as, future polarimeter concepts being considered under the NASA GSFC-led A-CCP study. Algorithms were developed and tested to simulate scattering angle sampling for precessing and sun-synchronous orbits. An intercomparison study was conducted to determine how scattering angle statistics varied in each orbit as a function of solar and viewing geometry, DOY, latitude, local time, equator crossing, and other factors. In addition, we examined how scattering angle varied with and within the polarimeters' swath width. Capturing these scattering angle dependencies will deepen our knowledge about how polarimeters characteristics can be better optimized and orbital requirements can be chosen with more insight to achieve high quality aerosol and cloud retrievals. In addition, these calculations will aid in the development of novel observational methodologies using polarimeters for future satellite constellation missions.

Toll, Velle

Observational constraint on cloud water response to aerosols based on polluted cloud tracks

Ship tracks have been long considered to be natural experiments of aerosol-cloud interactions. More recently, polluted cloud tracks induced by aerosols emitted from volcanoes and wildfires and various industrial sources - such as oil refineries, smelters, coal-fired power plants, and cities have been analysed (Toll et al. 2019; Nature, https://doi.org/10.1038/s41586-019-1423-9). In this research, we extend satellite observations of polluted cloud tracks from Toll et al. (2019) and Trofimov et al. (2020, https://doi.org/10.1029/2020JD032575) with analysis of smaller and larger scale polluted cloud areas detected in satellite images. Polluted clouds are detected in MODIS and SEVIRI satellite images as areas with strongly increased cloud droplet number concentrations. Both tens of kilometers wide ship-track-like polluted cloud tracks and hundreds by hundreds of kilometers wide polluted cloud areas show that cloud water can both increase and decrease in response to aerosols depending on meteorological conditions. On average, there is relatively weak decrease in cloud water. This weak decrease in cloud water offsets relatively small part of the Twomey effect. Meteorological dependence of cloud water responses can be compared to GCMs, where unidirectional cloud water increases are often assumed.

Larger-scale hundreds of kilometers wide cloud perturbations can be directly simulated in GCMs to compare models with observations.

Tsigaridis, Kostas

Clear-sky AOD in modeling

Tsikerdekis, Athanasios

Assimilating aerosol optical properties related to size and absorption from POLDER/PARASOL with an ensemble data assimilation system

A data assimilation system for aerosol, based on an ensemble Kalman filter, has been developed for the global aerosol model ECHAM-HAM and applied to POLDER derived observations of optical properties. The advantages of this assimilation system is that the ECHAM-HAM aerosol modal scheme carries both aerosol particle numbers and mass which are both used in the data assimilation system as state vector, while POLDER retrievals in addition to Aerosol Optical Depth (AOD) and Angstrom Exponent (AE) provide also information related to aerosol absorption like Aerosol Absorption Optical Depth (AAOD) and Single Scattering Albedo (SSA). The developed scheme can assimilate simultaneously combinations of multiple variables (e.g. AOD, AE, SSA), to optimally estimate mass mixing ratio and number mixing ratio of different aerosol species. We investigate the added value of assimilating AE, AAOD and SSA, in addition to the commonly used AOD, by conducting multiple experiments where different combinations of retrieved properties are assimilated. Results are evaluated with (independent) POLDER, MODIS Dark Target, MODIS Deep Blue and AERONET observations. The experiment where POLDER AOD, AE and SSA are assimilated shows systematic improvement in mean error, mean absolute error and correlation for AOD, AE, AAOD and SSA compared to the experiment where only AOD is assimilated. The same experiment reduces the global ME against AERONET from 0.072 to 0.001 for AOD, from 0.273 to 0.009 for AE and from -0.012 to 0.002 for AAOD. Additionally, sensitivity experiments reveal the benefits of assimilating AE over AOD at a second wavelength or SSA over AAOD, possibly due to a simpler observation covariance matrix in the present data assimilation framework. We conclude that the currently available AE and SSA do positively impact data assimilation.

Aerosol emission estimation using future satellite observation capabilities under the framework of Observing System Simulation Experiments (OSSEs)

Aerosol emission can be estimated by either a bottom-up approach, which aggregates known emission sources for an area, or a top-down approach (inverse modeling), where aerosol models and observations are combined to estimate aerosol emissions. The latter method holds the advantage of translating the new emission directly into aerosol forcing. In this study top-down aerosol emissions are estimated with a fixed-lag ensemble Kalman smoother which we here test with an Observing System Simulation Experiments (OSSEs), where a fully known reality is available for the evaluation of the system. In our OSSEs, an ECHAM-HAM simulation with altered aerosol emissions and nudged to the reanalysis ERA-Interim is used to create synthetic observations, specifically Aerosol Optical Depth (AOD), Angstrom Exponent (AE) and Single Scattering Albedo (SSA). The ensemble used by the data assimilation system is composed of 32 members, where emissions are perturbed with factors taken from a Gaussian distribution and each member is nudged to a meteorology defined by an ERA-5 ensemble member. Initially aerosol emission estimation is tested by assimilating the synthetic observations as a “perfect” satellite product, that includes low-uncertainty observations of AOD, AE and SSA over the whole globe and at all times. Subsequently, the system performance is tested by assimilating the synthetic observations according to the uncertainty and the spatiotemporal availability of future satellite measurements. Here, we focus on the NASA PACE mission, expected for launch late 2022 with 3 instruments onboard i) SPEXone, a hyperspectral multi-angle polarimeter instrument that aim for high accuracy measurements of the degree of linear polarization which will provide accurate characterization of aerosols in the atmosphere, for a narrow swath of 100 km ii) HARP-2, a hyperangular polarimeter with reduced accuracy compared to SPEXone but with a larger swath of 1500 km, and (iii) OCI, a hyperspectral radiometer that provides MODIS-like aerosol information at a wide swath of 2600 km. Orbit information is produced using an orbit simulator and retrieval uncertainties are estimated from retrievals on synthetic measurements, created by ECHAM-HAM (i.e. using different assumptions than the retrieval algorithm). Based on the results of the OSSEs we can assess the potential of the different sensors and their combination, as well as the performance of the emission estimation method (ensemble Kalman smoother).

Tsyro, Svetlana

Impacts of COVID-19 lockdown on European air quality

A preliminary analysis of the impact of emission drop caused by reduced activity due to COVID-19 lockdown on air pollution in European cities was performed within CAMS71 framework. The emission reduction estimates during the lockdown period were prepared by the Barcelona Computing Center (BCS). The dataset included a percentage decrease of all emissions from three activity sectors (Industry, Road Transport and Aviation) for all European countries. The EMEP model was used to perform hindcast simulations for the period from 1 March to 30 April, using CAMS v3.1_GNFR emissions with and without accounting for the emission reductions provided by BCS. The starting date of lockdown period in different countries (‘non-essential movement banned’) were taken from POLITICO research, Frontex, Oxford COVID-19 Government Response Tracker. The model results are compared with air quality observations reported to the EEA AQ e-reporting database. In addition, the source-receptor (SR) analysis was performed based on the EMEP model simulations with the purpose of quantifying the contribution of different sources to air pollution in European cities. We present the effect of COVID-19 related emission reduction on NO_2 and PM_{10} concentrations in eleven (ten for NO_2) large city areas, for which observational data were available. As expected, NO_2 concentrations decreased during the lockdown period compared to pre-COVID situation by 29% according to observations and by 46% according to model results on average at the measurement sites. The overall effect on PM_{10} is less obvious in the selected cities, as both concentration decreases and increases were observed and modelled. SR analysis, used for interpretation of these results, identified significant differences in air pollution patterns and dominating PM sources among the cities.

van Diedenhoven, Bastiaan

Aerosol properties inferred from the Research Scanning Polariemter (RSP) during the Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP2Ex)

The Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP2Ex) is a NASA field campaign that was conducted primarily over the ocean in the vicinity of the Philippines from 20 August to 10 October 2019. The Maritime continent is an extremely complex environment with a strong variability of aerosol and cloud properties. NASA's P-3 aircraft was outfitted with many in situ and remote sensing instruments to characterize aerosols, clouds and other atmospheric properties. Here we focus on remote sensing data from the Research Scanning Polarimeter, which is capable of inferring aerosol optical depth, size distributions, scattering and absorption properties and layer height information. We will provide an overview of the aerosol properties and conditions encountered, which include clean and polluted marine environments as well as heavy smoke events. We will discuss challenges inherent with such passive remote sensing data and how to interpret the results. Polarimetry observations are increasingly relevant, as NASA's Plankton, Aerosol, Cloud and ocean Ecosystem (PACE) satellite mission, to be launched in late 2022, will carry two high-accuracy multi-angle polarimeters. Moreover, polarimeters with enhanced spatial resolution and/or spectral range are considered for future missions.

Wandji, William

How close to sunshine-duration based AOD retrievals is the ECHAM aerosol load over Europe?

In the IPCC Fifth Assessment Report (IPCC, 2013), aerosols are mentioned as the largest contributor to the large uncertainties in the projections of climate change. A significant source in this uncertainty is linked to the limited knowledge of the historical evolution of aerosol load. Recently developed, a hybrid method is able to provide such historical aerosol optical depth (AOD) from long time series of sunshine duration measurements. We have applied the method over ~1000 ground-based stations in Europe yielding a unique new dataset of AOD starting from the late 19th century (Wandji Nyamsi et al., 2020). This communication aims to assess, for the first time ever, the accuracy of aerosol load included in the well-known atmospheric general circulation model ECHAM by comparing against sunshine-duration based AOD retrievals serving as reference over such long time period. In addition, similar comparisons between ECHAM and Global Energy Balance Archive (GEBA) data on surface solar irradiance are carried out over ~400 ground-based stations in Europe. The outcomes of this study will certainly open the way for a more accurate incorporation of aerosols in global climate models.

Watson-Parris, Duncan

Multi-model Perturbed Parameter Experiment update

I will update on both the Black Carbon and Cloud Multi-model Perturbed Parameter Experiments (MMPPEs) with particular emphasis on initial single model results, as constrained against Aeronet and in-situ aircraft observations.

Winker, Dave

An update on the NASA Aerosol-Cloud-Convection-Precipitation DO Study

The 2017 National Academies Earth Sciences Decadal Survey (DS) recommended science and applications priorities to be pursued by NASA during the 2017-2027 time frame. Aerosols (A) and clouds, convection, and precipitation (CCP) were identified as essential 'observables' requiring additional capabilities beyond those planned in the current Program of Record. The DS recommended NASA develop a medium-to-large mission to address these observables, which would serve as foundational elements of the future observing system. In fall 2018, NASA initiated a 3-year study of a combined ACCP observing system, including identification of science goals and objectives, desired geophysical variables, and observing system capabilities. The study is now completing its second year and beginning the preparation of recommendations to NASA management. The study has explored a large number of potential concepts that could provide desired observational capabilities, considering budget constraints and the planned international Earth observation program. We will present a summary of priority objectives for aerosol science, and mission approaches identified to date. We welcome feedback from the aerosol community.

Xie, Bing

The contributions of short-lived climate pollutants to global climate change since the pre-industrial era

Short-lived climate pollutants (SLCPs), a set of compounds with shorter lifetimes than well-mixed greenhouse gases, cause warming effect on climate. We used an online aerosol–climate model (BCC_AGCM2.0_CUACE/Aero) to simulate the total effective radiative forcing (ERF) and climate response to the changes in SLCP concentrations, including methane, tropospheric ozone, and black carbon, from the pre-industrial era to the present. The global annual mean ERF of SLCP was 0.99 [0.79-1.20] W m–2. Increased SLCP concentration led to warming effects over most parts of the globe, with the most obvious warming occurring in the mid-high latitudes of the Northern Hemisphere (NH) and the ocean around Antarctica, showing increases reaching 1.0 K. The changes in annual mean surface air temperature (SAT) caused by SLCP were more prominent in the NH (0.78 [0.62–0.94] K) than in the Southern Hemisphere SH (0.62 [0.45–0.74] K). SLCP have caused precipitation to increase by about 0.10 mm d–1 in mid-high latitudes and decreased by about 0.20 mm d–1 in subtropical regions. There was a northward shift in the Intertropical Convergence Zone (ITCZ) due to the interhemispheric asymmetry in SAT, which was an adverse effect induced by aerosols. Changes in SLCP concentrations caused increases in global annual mean SAT and precipitation of 0.70 K and 0.02 mm d–1, respectively. It is found in this work that SLCP had little effect on global average cloud cover. But the SLCP-induced cloud cover changes over regional scales are not negligible. SLCP has caused low cloud cover to increase by about 2.5% over high latitudes in the NH and the ribbon area near 60°S, whereas high cloud cover increased by more than 2.0% over northern Africa and the Indian Ocean. Finally, we compared the ERFs and global and regional warming effects of SLCP and carbon dioxide (CO_2). From 1850 to the present, the SLCP ERF was equivalent to 66%, 83%, and 50% of that of CO_2 in global, NH, and SH mean, respectively. The increases in SAT caused by SLCP were 43% and 52% of those by CO_2 over the globe and China, respectively.

Yang, Yang

Impacts of domestic emissions and regional transport on aerosol concentration, radiative forcing and climate during 1980–2018

As a result of air quality control regulations, aerosol emissions from developed countries in North America and Europe had decreased during recent decades. Meanwhile, emissions from developing countries in East Asia and South Asia had significantly increased because of rapid industrial and population growth. We quantified the source attribution of aerosols and examined relative roles of domestic emission and regional transport changes in long-term (1980-2018) trends of aerosol concentrations, direct radiative forcing (DRF) and climate over China, U.S., Europe and the Arctic using a global aerosol–climate model (Community Atmosphere Model, version 5) equipped with Explicit Aerosol Source Tagging (CAM5-EAST). We found that the impact of China's increasing domestic emissions on $PM_{2.5}$ (particulate matter less than 2.5 µm in diameter) concentrations over the last two decades of 20th century was partially offset by decreasing foreign emissions. A slowdown in the foreign emission reductions together with the weakening of winds explain 25% of China's increased post-2000 wintertime $PM_{2.5}$ trend. Meanwhile, increases in emissions from East Asia generally had a modest impact on US air quality, but mitigated the warming effect induced by reductions in US emissions by 25% in western US. Aerosol concentrations in Europe had a 62 % decrease during 1980–2018, the majority of which was contributed to reductions of local emissions in Europe. We also found that changes in sulfate and BC produced an Arctic surface warming of +0.3 K, explaining approximately 20 % of the observed Arctic warming since the early 1980s.

Yu, Fangqun

Use of machine learning to improve global models on aerosol-cloud interactions without compromising their computing efficiency

The effective radiative forcing (ERF) of anthropogenic aerosols associated with aerosol-cloud interactions (ERFaci) remains the largest source of uncertainty in climate prediction. The calculation of particle number concentration (PNC), one of the key parameters affecting ERFaci, is generally simplified in climate models to avoid expensive computing cost and thus contributes to the uncertainty in ERFaci. Here we employ outputs from long-term (30-years) simulations of a global size-resolved (sectional) aerosol microphysics model (GEOS-Chem-APM) and a machine-learning tool to develop a Random Forest Regression Model (RFRM) for PNC. The GEOS-Chem-APM contains several features of relevance towards the accurate simulation of PNC, including 40 bins to represent secondary particles, and the state-of-the-art nucleation mechanisms. GEOS-Chem-APM PNC simulations have been validated with a large number of in-situ measurements. The RFRM, trained on GEOS-Chem-APM outputs and can be applied to any global models with no or simplified aerosol microphysics, captures the complex dependence of PNC not only on aerosol mass concentrations but also on other important variables representing meteorological and chemical conditions. We have implemented the PNC RFRM in the version of GISS-ModelE2.1 with a mass-based One-Moment Aerosol (OMA) module, which is one of the models participating in CMIP6. The implementation of the PNC RFRM in GISS ModelE2.1-OMA significantly improves the agreement of its predicted PNC with measurements across the globe (both spatial distributions and temporal variations), weakens the relative changes of cloud droplet number concentration associated with changes of emissions from pre-industry to present-day, and reduces the ERFaci from -1.46 W·m−2 to -1.11 W·m−2. We further discuss the potential of using machine-learning as a novel method to improve global models in their ability to predict more accurately the response of critical aerosol properties (including cloud condensation nuclei and cloud droplet number concentrations, aerosol optical properties, etc.) to emission changes, and thus help to reduce uncertainties in the aerosol radiative forcing calculation of various models without having to deal with the complexity of size-resolved particle microphysics and compromising their computing efficiency, which is essential for long-term climate simulations.

Yu, Hongbin

Gigantic African Dust Intrusion into the Caribbean Basin and southern U.S. in June 2020

In late June of 2020, gigantic African dust plumes intruded into Caribbean Sea and affected a large swath of regions in the Americas, including the southern and northern Caribbean Basin, the Gulf of Mexico, the Central America, the tropical eastern Pacific Ocean, and the southeastern U.S. This paper characterizes this dust event using the MODIS and CALIOP remote sensing observations and the GEOS model simulations complemented by meteorological fields from the MERRA2 reanalysis and surface PM2.5 concentrations from the EPA air quality network. Our analysis of the full record of MODIS aerosol measurements reveals that this “Godzilla” dust event is historic in the recent two decades, with the peak aerosol optical depth up to 1.6 in the Greater Caribbean Basin and 0.8 in the Gulf of Mexico. The episode elevated the surface PM2.5 concentrations to a level exceeding the EPA air quality standard in 24% and 36% of sampling sites across the southeastern U.S. on June 26 and 27, respectively. Our analysis of MERRA2 meteorological fields suggests that the intense amount of dust observed in the Greater Caribbean Basin and beyond was a result of dust accumulation spanning over several days (June 14-17) in the eastern Atlantic Ocean and subsequent rapid westward transport controlled by anomalous drifting of the Bermuda-Azores High. We also characterize the evolution of three-dimensional structures of the dust plumes with the improved MODIS retrievals of non-spherical dust optical depth and fine-mode fraction, CALIOP observations of aerosol vertical profiles, and GEOS simulations of aerosol. Although GEOS model well captures the satellite observed trans-Atlantic movement of the gigantic dust plumes, the simulated aerosol optical depth is a factor of 2-5 lower than the MODIS retrievals in the Greater Caribbean Basin and the Gulf of Mexico. Contrary to what is revealed by MODIS observations, this dust event is not registered as a historic event in the context of GEOS multi-decadal simulations from 2000 onward. The GEOS simulated dust layer altitude is also lower than the CALIOP observations. Possible factors contributing to the large observation-model differences will be discussed.

Trans-Atlantic Dust Deposition (TADD): Evaluating GEOS simulation with satellite remote sensing products

Massive dust emitted from North Africa can transport long distances across the tropical Atlantic Ocean, reaching the Americas. Dust deposition along the transit adds microorganisms and essential nutrients to marine ecosystem, which has important implications for biogeochemical cycle and climate. However, assessing the dust-ecosystem–climate interactions has been hindered in part by the paucity of dust deposition measurements and large uncertainties associated with oversimplified representations of dust processes in current models. We have recently produced a unique dataset of dust optical depth, dust deposition flux, and dust loss frequency over the tropical Atlantic Ocean by using the decade-long (2007-2016) record of aerosol three-dimensional distribution from four satellite sensors, namely CALIOP, MODIS, MISR, and IASI. Dust loss frequency or removal efficiency is a useful diagnostic that makes it possible to disentangle the dust transport and removal processes from the dust emissions when identifying the major factors contributing to the uncertainties and biases in the model simulated dust deposition. In this study, we used the satellite-based dataset along with in situ observations to assess how well NASA GEOS model performs in simulating trans-Atlantic dust transport and deposition. We found that the GEOS modeling of dust deposition falls within the range of satellite-based estimates. However, this reasonable agreement in dust deposition is a compensation of the model's underestimate of dust emissions and overestimate of dust removal efficiency. Furthermore, the overestimate of dust removal efficiency results largely from the model's overestimate of rainfall rate. Our results provide insights into the model's deficiencies at process level, which could better guide model improvement. The analysis framework established in this study will be applied to examine multiple model simulations under the AeroCom Phase III experiments.

Zhang, Ying

Improved inversion of aerosol components in the atmospheric column from remote sensing data

Knowledge on the composition of atmospheric aerosols is important for reducing the uncertainty of climate assessment. In this study, an improved algorithm is developed for the retrieval of atmospheric columnar aerosol components from optical remote sensing data. This is achieved by using the complex refractive index (CRI) of a multicomponent liquid system in the forward model and minimizing the differences with the observations. The aerosol components in this algorithm comprise five species, combining eight sub-components including black carbon (BC), water-soluble (WSOM) and water-insoluble organic matter (WIOM), ammonium nitrate (AN), sodium chloride (SC), dust-like (DU), and aerosol water content in the fine and coarse modes (AWf and AWc). The calculation of the CRI in the multicomponent liquid system allows to separate the water-soluble components (AN, WSOM and AWf) in the fine mode and the SC and AWc in the coarse mode. The uncertainty in the retrieval results is analyzed based on the simulation of typical models, showing that the complex refractive index obtained from instantaneous optical-physical inversion compares well with that obtained from chemical estimation. The algorithm was used to retrieve the columnar aerosol components over China using the ground-based remote sensing measurements from the Sun-sky radiometer Observation NETwork (SONET) in the period from 2010 to 2016. The results were used to analyze the regional distribution and interannual variation. The analysis shows that the atmospheric columnar DU component is dominant in the northern region of China, whereas the AW is higher in the southern coastal region. The SC component retrieved over the desert in northwest China originates from a paleo-marine source. The AN significantly decreased from 2011 to 2016, by 21.9 mg m-2, which is inseparable from China's environmental control policies.

Zhang, Kai

Intercomparison of aerosol microphysics parameterizations in the MAM aerosol box model

The representation of aerosol microphysics in global aerosol models involves a number of physical and numerical assumptions, which in turn cause large differences in the simulated aerosol physical properties and lifecycle between models. Isolating the aerosol microphysics from the resolved atmospheric dynamics and other parameterized processes (e.g., clouds and radiation) helps to identify the root cause of model simulation differences, which is difficult for general intercomparison using global models. In this work, we extend the functionality of the Modal Aerosol Module (MAM) box model and compare different aerosol microphysics treatments that are typically used in global aerosol models. We find substantial differences in the simulated aerosol physical properties due to changes in the assumption for new particle formation and growth, aerosol wateruptake, and the coupling between individual aerosol microphysical processes.

Zheng, Jianyu

A New Retrieval Algorithm of the Thermal Infrared Optical Depth of Dust Aerosols based on the Combined CALIOP and IIR Observations

The direct radiative effects (DRE) of mineral dust aerosols at both shortwave solar (SW) and longwave thermal infrared (LW) radiation region are significant but remain uncertain. SW cooling effect at the top of atmosphere (TOA) has been investigated in decades with a good agreement while the LW warming effect was rarely evaluated and might be underestimated, urging a better understanding of the radiative properties of dust, in particular, the optical depth, in the thermal infrared (TIR). Despise most current remote sensing observations of dust aerosols are in the visible (VIS) region, the Infrared Radiometer (IIR) and the Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) onboard CALIPSO can be used to develop a new way to retrieve TIR dust optical depth (DOD). Firstly, the IIR provides brightness temperature (BT) observations in three TIR bands centered at 8.5, 10.8 and 12 μm, respectively. The difference between dust-laden BT and dust-free BT (dBT) is the signal for TIR DOD retrieval. Besides, CALIOP provides the accurate vertical location of dust and its optical depth at 532 nm. By using scatter properties of dust aerosol measured from the in-situ measurements with the vertical dust profiles, the estimated dust-laden, and dust-free BT are stimulated by the fast radiative transfer model using the discrete ordinated method (FASDOM), which can be used to obtain the estimated dBT further. By putting different AODs in the simulation, the look-up table of dBT as a function of AOD can be built up. Finally, the difference between observed BT with estimated dust-free BT can be located in the look-up table to retrieve TIR DOD.

Zhong, Qirui

Understanding the uncertainties in the modeling of biomass burning aerosols

Biomass burning (BB) aerosols pose significant impacts on air quality and earth climate system but are subject to large uncertainties in global and regional models at the current stage. We present a comprehensive analysis of AEROCOM model simulations with satellite observations to understand such uncertainties. 17 models from two AEROCOM Phase III experiments (Remote Sensing experiment and Biomass Burning emissions experiment) and 14 satellite products are involved. Two major fire regions (Amazon and South Hemisphere Africa) during the dry season are considered. Through the model-observation comparison, we interpret model AOD (aerosol optical depth) error in terms of model emissions and MEC (mass extinction coefficient). Model MEC is shown to correlate with model AE and SSA, suggesting observational constraints are possible on this important parameter We also try to correlate model AOD error with observed precipitation, relative humidity and formaldehyde concentrations. The satellite data is firstly evaluated against the AERONET observation, with the best agreement found by 4 Terra-MODIS products for the fire regions. Model AOD shows a linear response to biomass burning emissions. For the biomass burning experiment, in which all models used GFED v3, AOD was underestimated by 30-70%. For the Remote Sensing experiment, with different emission inputs for models, the model bias in AOD ranges from -75% to 11%. Greater underestimation of AOD is found in Amazonia than in Africa. A significant positive correlation between emissions and aerosol load across the AEROCOM experiments is found, suggesting that the models simulate a similar aerosol lifetime. However, the MECs for the models differ a lot. It is estimated that the variation of emissions and MEC contribute by 42% and 31% to the different AOD simulated by the models. To further explain model error, we perform regression analysis on AOD with a set of observed parameters (precipitation, relative humidity, formaldehyde concentrations). These parameters relate to major processes in aerosol modeling. Our results indicate that observed formaldehyde can be a good predictor of model AOD error over the Amazon but not over South Hemisphere Africa, which suggests missing SOA processes in the models. The relative humidity and precipitation are also found to be able to represent parts of the model AOD error, indicating the possible bias in hygroscopic growth and wet deposition in models.

Zuidema, Paquita

Modeling the smoky troposphere of the southeast Atlantic: a comparison to ORACLES airborne observations from September of 2016

In the southeast Atlantic well-defined smoke plumes from Africa advect over marine boundary layer cloud decks; both are most extensive around September, when most of the smoke resides in the free troposphere. A framework is put forth for evaluating the performance of a range of global and regional atmospheric composition models against observations made during the NASA ORACLES (ObseRvations of Aerosols above CLouds and their intEractionS) airborne mission in September 2016. A strength of the

comparison is a focus on the spatial distribution of a wider range of aerosol composition and optical properties than has been done previously. The sparse airborne observations are aggregated into 2o grid boxes and into three vertical layers: the cloud-topped MBL, the layer from cloud top to 3 km, and the 3-6 km layer. Simulated aerosol extensive properties suggest that the flight-day observations are reasonably representative of the regional monthly average, with systematic deviations of 30 % or less. Evaluation against observations indicates that all models have strengths and weaknesses, and there is no single model that is superior to all the others in all metrics evaluated. Whereas all six models typically place the top of the smoke layer within 0-500 m of the airborne lidar observations, the models tend to place the smoke layer bottom 300-1400 m lower than the observations. A spatial pattern emerges, in which most models underestimate most smoke quantities (black carbon, extinction, carbon monoxide) further offshore in the 3-6 km layer, and overestimate the same quantities further south, closer to the coast, where less aerosol is present. Model representations of the above-cloud aerosol optical depth differ more widely. Most models overestimate the organic aerosol mass concentrations relative to those of black carbon, and with less skill, indicating model uncertainties in secondary organic aerosol processes. Regional-mean free-tropospheric model single scattering albedos vary widely, between +/-0.06 of in situ measurements centered around 0.86, despite minimal impact of humidification on particulate scattering. Modeled ratio of the particulate extinction to the sum of the black carbon and organic aerosol mass concentrations (a mass extinction efficiency proxy) are typically too low and vary too little spatially, with significant inter-model differences. Most models overestimate the carbonaceous mass within the offshore boundary layer. Overall, the diversity in the model biases suggests that different model processes are responsible. The wide range of model optical properties requires further scrutiny because of their importance for radiative effect estimates.