ABSTRACTS

of presentations during the

13th AeroCom Workshop

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in alphabetical order by presenter

ORAL title
POSTER title

Arola, Antti

Assessment of cloud related fine mode AOD enhancements based on AERONET SDA product

AERONET (AErosol RObotic NETwork), which is a network of ground-based sun photometers, includes also so-called Aerosol Spectral Deconvolution Algorithm (SDA) that utilizes spectral total extinction AOD data to infer the component fine and coarse mode optical depths at 500nm. Based on its assumptions, SDA identifies cloud optical depth as the coarse mode AOD component and therefore effectively computes the fine mode AOD also in mixed cloud-aerosol observations. Therefore, it can be argued that the more representative AOD for fine mode fraction should be based on all direct sun measurements and not only on those cloud-screened for clear-sky conditions, in other words on those from Level 1 (L1) instead of Level 2 (L2). The objective of our study was to assess, including all the available AERONET sites, the magnitude of this cloud enhancement in fine mode AOD, in other words contrasting SDA L1 and L2 in our analysis. Assuming that the cloud-screening correctly separates the cloudy and clear-sky conditions, then the increases in fine mode AOD can be due to various cloud-related processes, mainly by in-cloud processing and hygroscopic growth. We estimated these cloud-related enhancements in fine mode AOD seasonally and found, for instance, than in June-July season the average over all the AERONET sites was 0.034, when total fine mode AOD from L2 data was 0.192, therefore the relative enhancement was 18%. It is difficult to separate the fine mode AOD enhancements due to in-cloud processing and hygroscopic growth, but we attempted to get some understanding by conducting a similar analysis for SDA-based fine mode Angstrom Exponent patterns. Moreover, we included OMI NO2 and Glyoxal data, to infer whether the regional patterns of fine mode AOD enhancements contain similar features than these two data products that could serve as a proxy of the strength of in-cloud processing.

Balkanski, Yves

An intercomparison of total and soluble iron deposition across AEROCOM models

Deposition fields of soluble iron have not been compared throughout the different atmospheric models as of now. We propose to provide to all other groups the iron content as a function of the geographical location dust emission regions based upon Journet et al. (2014). All models with an interactive dust cycle will estimate the total iron deposited over both oceanic and terrestrial surfaces Deposition fields from each model will be evaluated using a database of several hundred measurements assembled from the literature. Soluble iron is a limiting nutrient for phytoplankton in so-called HPLC (High Productivity, Low Chlorophyll) regions. Several models are currently developing parametrizations to compute the soluble iron. The processes that are considered include pH variations due to acids during evaporation /condensation, and the increase in solubility within the fine fraction (clays). A recent database put together by Sholkovitz et al. (2012) provides the means to evaluate if models predict correctly the distribution of soluble iron both in the atmosphere and in the ocean and consider the importance of the different processes that play a role on iron solubility. An evaluation of soluble iron will be carried out by

comparison to global datasets containing several thousands of samples collected over the open ocean.

Ban-Weiss, George

Evaluating clouds, aerosols, and their interactions in three global climate models using satellite simulators and observations

Accurately representing aerosol-cloud interactions in global climate models is challenging. As parameterizations evolve, it is important to evaluate their performance with appropriate use of observations. In this investigation we compare aerosols, clouds, and their interactions in three global climate models (GFDL-AM3, NCAR-CAM5, GISS-ModelE2) to MODIS satellite observations. Modeled cloud properties are diagnosed using a MODIS simulator. Cloud droplet number concentrations (N) are computed identically from satellite-simulated and MODIS-observed values of liquid cloud optical depth and droplet effective radius. We find that aerosol optical depth (τa) simulated by models is similar to observations in many regions around the globe. For N, AM3 and CAM5 capture the observed spatial pattern of higher values in coastal marine stratocumulus versus remote ocean regions, though modeled values in general are higher than observed. Aerosol-cloud interactions were computed as the sensitivity of ln(N) to ln(τa) for coastal marine liquid clouds near South Africa (SAF) and Southeast Asia (SEA) where τa varies in time. AM3 and CAM5 are more sensitive than observations, while the sensitivity for ModelE2 is statistically insignificant. This widely used sensitivity could be subject to misinterpretation due to the confounding influence of meteorology on both aerosols and clouds. A simple framework for assessing the sensitivity of ln(N) to ln(τa) at constant meteorology illustrates that observed sensitivity can change from positive to statistically insignificant when including the confounding influence of relative humidity. Satellite-simulated versus standard model values of N from CAM5 are compared in SAF; standard model values are significantly lower with a bias of 83 cm-3.

Bian, Huisheng

AeroCom III nitrate experiment: An integrated assessment using multi-model simulations and measurements from ground stations, aircrafts, and satellite

The first AeroCom nitrate model experiment has been proposed during the 2013 AeroCom workshop in Hamburg, Germany. The nitrate experiment will (1) address the diversity of nitrate simulations by the AeroCom model and understand the reasons for the intermodal differences, (2) compare model simulated nitrate with measurements from ground networks, aircraft campaigns, and satellite retrievals, and (3) investigate how nitrate formation changes in different models in response the perturbation of precursor emissions and meteorological conditions. We will discuss here the questions raised during the experiment and the list of output fields that helps in revealing the causes of diversity. We will also try to present preliminary results based on the progress of the experiment.

Chin, Mian

Aerosol source attributions and source-receptor relationships across the Northern Hemisphere - Initial results from HTAP2/AeroCom3 model experiments

The second phase of the UN Task Force on Hemispheric Transport of Air Pollution (HTAP2) is to better assess the impact of intercontinental transport of air pollution on regional and global air quality, ecosystems, and near-term climate change. AeroCom contributes to HTAP2 through a coordinated multiple model simulations (in AeroCom phase III) and data managements. We present here the initial results from HTAP2/AeroCom3 model experiments. We will (a) evaluate the model results with surface and aircraft measurements, (b) examine the relative contributions of regional emission and extra-regional source on surface PM concentrations and column aerosol optical depth (AOD) over several NH pollution and dust source regions and the Arctic, and (c) quantify the source-receptor relationships in the pollution regions that reflect the sensitivity of regional aerosol amount to the regional and extra-regional emission reductions.

DeLeeuw, Gerrit

ATSR retrievals of aerosol and clouds

Dhomse, Sandip

Aerosol microphysics simulations of the Mt. Pinatubo eruption with the UKCA composition-climate model

We use a stratosphere-troposphere composition-climate model with interactive sulphur chemistry and aerosol microphysics, to investigate the effect of the 1991 Mount Pinatubo eruption on stratospheric aerosol properties. Satellite measurements indicate that shortly after the eruption between 14 and 23 Tg of SO2 (7 to 11.5 Tg of sulphur) was present in the tropical stratosphere. Best estimates of the peak global stratospheric aerosol burden are in the range 19 to 26 Tg, or 3.7 to 6.7 Tg of sulphur assuming a composition of between 59 and 77% H2SO4. In light of this large uncertainty range, we performed two main simulations with 10 and 20 Tg of SO2 injected into the tropical lower stratosphere. Simulated stratospheric aerosol properties through the 1991 to 1995 period are compared against a range of available satellite and in-situ measurements. Aerosol optical depth (AOD) and effective radius from both simulations show good qualitative agreement with the observations, with the timing of peak AOD and decay timescale matching well with the observations in the tropics and mid-latitudes. However, injecting 20 Tg gives a factor two too high stratospheric aerosol mass burden compared to the satellite

data, with consequent strong high biases in simulated AOD and surface area density, with the 10 Tg injection in much better agreement. Our model cannot explain the large fraction of observed sulphur injection that was removed within first few months after the eruption. This indicates that there must be an additional alternative loss pathway for the SO2, possibly involving ash or ice in the volcanic cloud that is not included in our model. We also critically evaluate the simulated evolution of the particle size distribution, comparing in detail to balloon-borne optical particle counter (OPC) measurements from Laramie. Overall, the model captures remarkably well the complex variations in particle concentration profiles across the different OPC size channels. However, for the 19 to 27 km injection height-range used here, both runs have a modest high bias in the lowermost stratosphere for the finest particles (radii less than 250nm), and the decay timescale is longer in the model for these particles, with a much later return to background conditions. Also, whereas the 10 Tg run compared best to the satellite measurements, a significant low bias in the coarser size channels is apparent in the volcanically perturbed lower stratosphere. Nevertheless, our results suggest that, with appropriate calibration, aerosol microphysics models are capable of capturing the observed variation in particle size distribution in the stratosphere across both volcanically perturbed and quiescent conditions. Furthermore, additional sensitivity simulations suggest that predictions with the models are robust to uncertainties in sub-grid particle formation and nucleation rates in the stratosphere.

Dunne, Eimar

Comparison of AeroCom models with marine observations

In remote marine regions, the lack of regular observations is a severe limitation on our assessment of model performance. A collection of marine observational data sets will be compared with a selection of four AeroCom models to assess their performance in marine regions. The data sets include aerosol size distributions, CCN concentrations, bulk Na+ mass, and aerosol optical properties. They originate from multiple sources, including ACE1, ACE2, AERONET/MAN, ASCOS, OSSA and VOCALS. Particular attention is paid to data from the recent ARM MAGIC cruises, a unique asset comprising in-situ aerosol and cloud measurements from multiple cruise legs between Los Angeles and Hawaii, over both the warm and cold seasons. The four models included in the initial assessment are CAM4-OSLO-Vcmip5, ECHAM-SALSA, GLOMAP Mode v6R, and HadGEM3-A-GLOMAP. More models can be added in the future.

Fahey, **David**

Reflections on aerosols and climate and the future

Aerosols play a complex and varied role in Earth's climate system. Understanding that role and projecting it into the future requires sustained investments in global aerosol models and comprehensive atmospheric observations. Mitigation of aerosol effects to protect climate and health requires improved understanding of aerosol processes. The AeroCom project occupies a central coordinating role in aerosol issues by bringing together observations and modeling from international communities in a detailed way with the objective to promote this understanding. My NOAA research

group has contributed to this effort in recent years with our experimental studies on black carbon in the atmosphere and remains interested in continuing this role. I will reflect on this work and segue to other topics such as our interests in bioaerosol and stratospheric sulfate aerosol.

Fairlie, **T.Duncan**

Persistence of ash in the tropical stratosphere following the eruption of Mt. Kelud, 2014

An increase in stratospheric aerosol loading in the last 15 years has been linked to episodic volcanic eruptions in tropical latitudes, and is thought to have contributed to the recent global warming hiatus. The climate impact of volcanic aerosol normally assumes a purely sulfate composition in the stratosphere with associated optical properties. Here we show remote and in-situ observations that indicate that ash can persist in a stratospheric volcanic plume months after the eruption. On 13 February, 2014, the Mt. Kelud (Java) volcano injected material into the tropical lower stratosphere as high as 26 km. The initial eruption and subsequent dispersion of the plume in tropical latitudes were captured by the CALIPSO lidar. Initial depolarization measurements at 532 nm of ~0.3-0.4 indicated the presence of irregularly shaped ash particles in the plume, while a reduction of depolarization to ~0.1-0.2 in the following month was consistent with formation of spherical sulfate particles, but with a persistent ash component. In May 2014, we conducted a field campaign, based in Darwin, Australia to make in-situ balloon-borne measurements of the Kelud volcanic plume, to characterize particle size, optical properties, and the volatile fraction of the aerosol. We conducted four flights of two-channel Compact Optical Backscatter Aerosol Detector (COBALD) backscatter sondes under small balloons, and a single flight of combined heated and unheated Optical Particle Counters (OPCs) with a COBALD under a large balloon. The observations show a double peak of backscatter in the vertical, and confirm the presence of larger non-volatile particles in the lower part of the plume.

Feingold, Graham

Lessons from higher LES modeling on aerosol-cloud interactions

Feldman, Daniel

Diagnostics from the Radiative Forcing Model Intercomparison Project

The Radiative Forcing Model Intercomparison Project (RFMIP) will assess sources of error and spread in the radiative forcing calculated by state-of-the-art climate models for historical and future climate studies. RFMIP consists of three linked components: one assessing the forcing by greenhouse gases,

one the forcing by natural and anthropogenic aerosols, and one linking these with estimates of effective forcing inferred from global model integrations via careful diagnosis. Each component relies on intensive calculations and analysis. These include very large-scale reference calculations for forcing by greenhouse gases and aerosols using computationally-intensive line-by- line radiative transfer models, careful and consistent diagnosis of aerosol radiative properties, and the systematic construction of a set of radiative kernels useful for diagnosing forcing, including one for each model and one based on observations. The results of these calculations aim to provide benchmarks for the two largest sources of direct forcing against which model calculations can be compared, forming the basis for metrics of climate model performance in this crucial area.

Ferrare, Rich

Comparisons of Airborne HSRL and Modeled Aerosol Profiles

Aerosol profiles derived from a regional and a global model are compared with aerosol profiles acquired by NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidars (HSRLs) during recent field missions. We compare simulated aerosol profiles obtained from the WRF-Chem regional model with those measured by the airborne HSRL-2 instrument over the Atlantic Ocean east of Cape Cod in July 2012 during the Department of Energy Two-Column Aerosol Project (TCAP). While deployed on the LaRC King Air during TCAP, HSRL-2 acquired profiles of aerosol extinction at 355 and 532 nm, as well as aerosol backscatter and depolarization at 355, 532, and 1064 nm. Additional HSRL-2 data products include profiles of aerosol type, mixed layer depth, and aerosol microphysical parameters (e.g. effective radius, concentration). The HSRL-2 and WRF-Chem aerosol profiles are compared along the aircraft flight tracks. HSRL-2 profiles acquired during the NASA Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) mission over Houston during September 2013 are compared with the NASA Goddard Earth Observing System global model, version 5 (GEOS-5) profiles. In addition to comparing backscatter and extinction profiles, the fraction of aerosol extinction and optical thickness from various aerosol species from GEOS-5 are compared with aerosol extinction and optical thickness contributed by aerosol types derived from HSRL-2 data. We also compare aerosol profiles modeled by GEOS-5 with those measured by the airborne LaRC DIAL/HSRL instrument during August and September 2013 when it was deployed on the NASA DC-8 for the Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS) mission. DIAL/HSRL measured extinction (532 nm), backscatter (532 and 1064 nm), and depolarization profiles (532 and 1064 nm) in both nadir and zenith directions during long transects over the continental United States. DIAL/HSRL measurements acquired during SEAC4RS allow comparisons with GEOS-5 simulations of forest fire smoke over the western U.S. The fraction of aerosol extinction attributed to dust derived from the DIAL/HSRL depolarization measurements are compared with the corresponding GEOS-5 dust simulations.

Dave Fillmore

Regional Aerosol Optical Depth Trends and Interannual Variability with MATCH, CCCM and MODIS

We examine global and regional aerosol optical depth trends and inter-annual variability from 2000 - present with the Model for Atmospheric Transport and Chemistry (MATCH). MATCH assimilates MODIS AOD and thus augments the satellite data with model information on aerosol type and vertical distribution. With the MATCH assimilation we reduce the effects of MODIS spatial sampling on the trend analysis. The merged CERES CALIPSO CloudSat MODIS (CCCM) A-Train dataset provides aerosol layer distributions from 2007 through 2010. Over this time period we examine the seasonal and inter-annual variability in the vertical distribution of AOD for select regions of interest. We also discuss the potential of CCCM for aerosol transport model validation, using MATCH as an example.

G. Frost

Emissions for global modeling - trends and uncertainties

Accurate and timely global emissions estimates for trace gases and aerosols are critical to atmospheric chemistry research and are key inputs to earth system models. I will present comparisons of current global and regional inventory predictions of multi-decadal emissions changes. I will outline some emissions uncertainties suggested by these inventory comparisons and by using observational constraints. I will discuss an effort to develop a new community global historical emission inventory for chemistry-climate projects. I will conclude with the international activities GEIA and ECCAD, which provide access and facilitate analysis of emissions data.

Gettelman, Andrew

Putting the clouds and their uncertainties back into Aerosol-Cloud-Interactions

Aerosol Cloud Climate Interactions (ACI) are sensitive not just to the aerosol distribution, but also to the representation of clouds. The complexities of the cloud response to aerosol perturbations are explored by looking at a comprehensive global model with a detailed aerosol and cloud description, and trying to extract simple relationships between bulk aerosol properties (such as AOD, aerosol mass and CCN) and the response of cloud microphysics and radiation. The results are complex. The response of clouds, and the resulting cloud radiative effects to aerosols can only be understood in the context of different effects in regimes: different regions and different seasons. Simple bulk formulas are unlikely to capture the complexity of the results. This complexity may provide a path forward for comparing models to each other, and to targeted observations in specific cloud regimes.

Ghan, Steve

Multi-Model Analysis of Aerosol Effects on Clouds Simulated by Global Climate Models

Estimates of effective radiative forcing by aerosol-cloud interactions (ERFaci) have varied widely. These differences arise from differences in the simulation of multiple factors, including differences in emissions of aerosols and precursor gases, the efficiency of the production of cloud condensation nuclei (CCN) from the emissions, the sensitivity of cloud droplet number concentration to increases in CCN concentration, the sensitivity of cloud optical depth to increases in droplet number concentration, and the sensitivity of the planetary energy balance to changes in the cloud optical depth. The relative contributions of each of these factors to uncertainty in the estimated ERFaci have not been quantified. We have decomposed the ERFaci simulated by a variety of global aerosol models into these factors. We find that much of the uncertainty ERFaci is due to uncertainty in the response of droplet number to anthropogenic changes in CCN concentration and in the response of cloud liquid water path to changes in droplet number concentration. We will show examples of how observations can be used to constrain simulated values of each of the factors.

Holzer-Popp, Thomas

AeroSAT

Summary of discussions and conclusions from the preceding AeroSAT meeting

Huttunen, Jani

Aerosol direct radiative effect efficiency, aerosol optical properties and surface albedo - comparison between simulations of models and results derived with measurements

In this study, observational based aerosol direct radiative effect efficiency (ADREE), aerosol optical properties and surface albedo are compared with model simulations. The aerosol direct radiative effect, attenuation of the solar flux due to scattering and absorption of aerosols, normalized by the Aerosol Optical Depth (AOD), ADREE, is simulated by several models and the estimates are compared with the results based on measurements. AODs are collected from the Aerosol Robotic Network (AERONET) and solar flux measurements are from Solar Radiation Network (http://solrad-net.gsfc.nasa.gov/) and Baseline Surface Radiation Network (http://www.bsrn.awi.de/). The models are from the Aerosol Comparisons between Observations and Models (AeroCom, aerocom.met.no) Phase II experiment. ADREE is defined for clear sky and daily averaged ADREEs at the surface are determined at

over 20 stations. The stations are selected from various parts of the earth, covering different aerosol optical properties. For the same stations, aerosol optical properties for few wavelength bands are compared between models and products based on sun and sky measurements. The aerosol optical properties are AOD, Absorption AOD, Single Scattering Albedo (SSA) and they are provided from AERONET, including surface albedo. The main part of the study is to compare ADREE, but a comparison of the above mentioned parameters is included to explain possible discrepancies. The preliminary results of six models show that discrepancies exist. Often the models provide weaker magnitude of ADREE especially when measurement based ADREE is stronger than -80 Wm-2. Preliminary, model simulations more frequent underestimate aerosol absorption than overestimate it based on this analysis, and this is in the line with studies of modellers. The number of models included in the study will be increased to over ten during 2014 and the study will be finalized in early 2015. In the near future, this analysis will be extended to the top of the atmosphere using satellite products. Then, for example simulated aerosol absorption in the atmosphere by models is possible to validate more precisely.

Ichoku, Charles

Top-Down Biomass-Burning Aerosol Emissions hold great promise for Global and Regional Modeling

Accurate representation of biomass burning emissions in models has hitherto been challenging because of the inherent difficulty in quantifying these emissions at appropriate time and space scales using traditional bottom-up methods. Over the last couple of decades, satellite remote sensing has become an indispensable technique for characterizing smoke aerosol emissions from open biomass burning, especially at regional to global scales. These fires are detected from space because of the intense heat energy they generate and the corresponding smoke plumes that comprise different species of aerosols and trace gases. A series of recent studies have revealed that both the biomass consumption and emissions of aerosol and trace gases by open biomass burning are directly proportional to the fire radiative energy (FRE), whose instantaneous rate of release or fire radiative power (FRP) is measurable from space. We have leveraged this relationship to generate a global, gridded smoke-aerosol emission coefficients (Ce) dataset based on FRP and aerosol optical thickness (AOT) measurements from the MODIS sensors aboard the Terra and Aqua satellites. Ce is used to convert FRE to smoke aerosol emissions, in the same manner as traditional emission factors are used to convert burned biomass to emissions. The first version of this Fire Energetics and Emissions Research (FEER.v1) global gridded emission product at 1°x1° resolution is available at feer.gsfc.nasa.gov. The FEER.v1 emission products have been compared with several other major satellite-based emissions inventories both as inputs and outputs of regional aerosol simulations, and the top-down emissions are showing a great promise when compared to satellite aerosol retrievals. It is concluded that an AeroCom experiment will provide an important, critical test of the relative strengths of top-down and bottom-up emissions inventories for model initialization at the global scale. In this presentation we will show the results from the regional analyses and propose an augmentation to the current AeroCom experiment evaluating biomass burning emissions inputs, in order to explore the relative advantages of top-down emission coefficients based on satellite FRP and AOT observations, and those of emission factors derived from bottom-up approaches.

Jethva, Hiren

Retrieval, Inter-comparison, and Validation of Above-cloud Aerosol Optical Depth from A-train Sensors

Absorbing aerosols produced from biomass burning and dust outbreaks are often found to overlay lower level cloud decks as evident in the satellite images. In contrast to the cloud-free atmosphere, in which aerosols generally tend to cool the atmosphere, the presence of absorbing aerosols above cloud poses greater potential of exerting positive radiative effects (warming) whose magnitude directly depends on the aerosol loading above cloud, optical properties of clouds and aerosols, and cloud fraction. Recent development of a 'color ratio' (CR) algorithm applied to observations made by the Aura/OMI and Aqua/MODIS constitutes a major breakthrough and has provided the unprecedented maps of above-cloud aerosol optical depth (ACAOD). The CR technique employs reflectance measurements at TOA in two channels (354 and 388 nm for OMI; 470 and 860 nm for MODIS) to retrieve ACAOD in near-UV and visible regions and aerosol-corrected cloud optical depth, simultaneously. An inter-satellite comparison of ACAOD retrieved from NASA's A-train sensors reveals a good level of agreement between the passive sensors over the homogeneous cloud fields. While the unprecedented quantitative information on aerosol loading above cloud is now available from A-train sensors, a greater question remains ahead: How to validate the satellite retrievals of above-cloud aerosols (ACA)? Direct measurements of ACA such as carried out by the NASA Ames Airborne Tracking Sunphotometer (AATS) and Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research (4STAR) can be of immense help in validating ACA retrievals. We validate the ACA optical depth retrieved using the 'color ratio' (CR) method applied to the MODIS cloudy-sky reflectance by using the airborne AATS and 4STAR measurements. A thorough search of the historic AATS-4STAR database collected during different field campaigns revealed five events where biomass burning, dust, and wildfire-emitted aerosols were found to overlay lower level cloud decks observed during SAFARI-2000, ACE-ASIA 2001, and SEAC4RS-2013, respectively. The co-located satellite-airborne measurements revealed a good agreement (RMSE less than 0.1 for AOD at 500 nm) with most matchups falling within the estimated uncertainties in the MODIS retrievals. An extensive validation of satellite-based ACA retrievals requires equivalent field measurements particularly over the regions where ACA are often observed from satellites, i.e., south-eastern Atlantic Ocean, tropical Atlantic Ocean, northern Arabian Sea, South-East and North-East Asia.

Jiang, Yiquan

Wild fire climate effects simulated by NCAR Community Earth System Model

This study investigates the wild fire climate effects with the NCAR Community Earth System Model 1.2 (CESM1.2), a state-of-the-art climate model considering aerosol's direct, semi-direct and indirect

effects. The MAM4 aerosol module is applied in experiments and fire snow forcing is diagnostic with snow, ice, and aerosol radiative model (SNICAR). The fire BC snow forcing is most significant during spring in Northeast Asia and significant surface warming is found there. An anti-cyclone anomaly of low troposphere is found located at North Pacific Ocean of downstream warming areas. In summer, indirect effects of fire POM is dominant in North hemisphere. The enhanced short wave cloud forcing (more negative), increased low-level cloud and cloud liquid water path are found in Canada, Alaska and North East Asia due to fire POM. Decreased surface air temperature and suppress of precipitation are found in corresponding areas.

Johnson, Ben

Simulation of biomass burning aerosols in HadGEM3

Biomass burning emissions are one of the largest sources of absorbing aerosols globally. Their impact on global and regional climate is highly dependent on the accurate representation of BB emissions, aerosol processes and the resulting aerosol properties. Key uncertainties include the total emission rate, injection height, and the fraction of black carbon vs organic carbon that it emitted. The simulation of BB aerosol properties has been substantially improved in the Met Office Hadley Centre Global Environment Model (HadGEM3) with the introduction of GLOMAP-mode, a modal aerosol scheme developed as part of United Kingdom Chemistry and Aerosol project (UKCA). The aerosol size distribution, composition and absorption properties are shown to compare well against recent observations from the South American Biomass Burning Analysis (SAMBBA). However, it remains necessary to scale GFED3.1 emissions up by a factor of 2 - 4 to gain agreement with observed AODs and mass concentrations. The necessary scaling factor depends on the assumed injection height and the efficiency of aerosol wet removal processes. These findings will be demonstrated with HadGEM3 simulations contributing to the phase III experiment on biomass burning.

Kahn, Ralph

MISR Aerosol Type Strengths and Limitations

We have completed the formal validation of the Version 22 MISR Aerosol Type product, have diagnosed remaining issues, and have identified possible improvements using the MISR Research Aerosol algorithm. We also determined a way to assess the quality of individual aerosol type retrievals. Aerosol Type is a categorical variable derived by combining aerosol “size” (three-to-five bins under good retrieval conditions, e.g., “small,” “medium,” “large”), SSA (two-to-four bins), and spherical vs. non-spherical particle shape. For modelers, using this product can be challenging: it is categorical rather than quantitative, and the quality varies more with retrieval conditions than AOD. However, global aerosol type measurements are currently not available from any other source. This presentation will cover how MISR aerosol type is being applied, and what we are doing to make it easier.

Kalashnikova, Olga

Constraining aerosol surface loadings by combining multiangular and polarimetric remote sensing with chemical transport model information

We present a methodology for combining Chemical Transport Model (CTM) aerosol type information and multiangular spectropolarimetric data to establish the signature of specific aerosol types in top-of-atmosphere measurements, and relate it to speciated surface PM2.5 loadings. In particular, we employ the WRF-Chem model run at the University of Nebraska, and remote sensing data from the Airborne Multiangle SpectroPolarimetric Imager (AirMSPI) to explore the feasibility of this approach. We demonstrate that the CTM does well in predicting the types of aerosols present at a given location and time, however large uncertainties currently exist in CTM estimates of the concentration of the various aerosol species (e.g., black carbon, sulfate, dust, etc.) leading to large uncertainties to model-derived speciated PM 2.5. In order to constrain CTM aerosol surface concentrations we use AirMSPI UV-VIS-NIR observations of intensity, and blue, red, and NIR observations of the Q and U Stokes parameters. We select specific scenes observed by AirMSPI and use WRF-Chem to generate an initial distribution of aerosol composition. The relevant optical properties for each aerosol species are used to calculate aerosol light scattering information. This is then used in a vector (polarized) 1-D radiative transfer model to determine at-instrument Stokes parameters for the specific AirMSPI viewing geometries. As a first step, a match is sought between the CTM-predicted radiances and the AirMSPI observations. Then, the total aerosol optical depth and fractions of various aerosol species are modified via optimization to better fit the observations, and converted to PM2.5 speciated loadings using CTM aerosol vertical profiles. Finally, the results are compared to available ground-based and in situ data to validate this approach.

Kim, Dongchul

A multi-model analysis and comparison with remote-sensing data of North African dust

North African dust is investigated using five global models that participated in the AeroCom phase II model experiments and multi remote-sensing observations of aerosol optical depth (AOD) data from MODIS, MISR, and SeaWiFS, dust optical depth (DOD) derived from MODIS and MISR, AOD and coarse-mode AOD (as a proxy of DOD) from ground-based AERONET sun-photometer measurements, and dust vertical distributions from CALIOP and centroid height from AIRS satellite AODs. Focusing on small number of participating models we examine the following quantities of AOD and DOD: (1) the magnitudes in our study domain, (2) the longitudinal gradient of dust during North Atlantic transport, (3) seasonal variations at different locations, and (4) the dust vertical profile shape and the AOD centroid height. Although different satellite data show consistent features in most of these aspects, the models display large diversity in all of them, with significant differences among the models and

between models and observations. We also found remarkable differences in dust emission, removal, and mass extinction efficiency in the five models, that all contribute to the discrepancies of model simulated dust amount and distribution. This study highlights the challenges in simulating the dust physical and optical processes, even in the best-known dust environment, and stresses the need for observable quantities to constrain the model processes.

Kinne, Stefan

The MPI-M Aerosol Climatology (MAC)

Monthly gridded global data-sets for aerosol optical properties (AOD, SSA and g) and for aerosol microphysical properties (CCN and IN) offer a (less complex) alternate path to include aerosol radiative effects and aerosol impacts on cloud-microphysics in global simulations. Based on merging AERONET sun-/sky-photometer data onto background maps provided by AeroCom phase 1 modeling output and AERONET sun-/the MPI-M Aerosol Climatology (MAC) version 1 was developed and applied in IPCC simulations with ECHAM and as ancillary data-set in satellite-based global data-sets. An updated version 2 of this climatology will be presented now applying central values from the more recent AeroCom phase 2 modeling and utilizing the better global coverage of trusted sun-photometer data - including statistics from the Marine Aerosol network (MAN). Applications include spatial distributions of estimates for aerosol direct and aerosol indirect radiative effects.

Kirkevag, Alf

Preliminary estimates of Aerosol Effective Radiative Forcing in CAM5-Oslo

We present preliminary effective radiative forcing (ERF) results from simulations with CAM5-Oslo, using nudged meteorology from CAM5 and IPCC AR5 emissions of aerosols and precursors for PD (2000) and PI (1850) conditions. The model, an early version of the next generation atmospheric module of the Norwegian Earth System Model, NorESM1 (Bentsen et al., 2013; Iversen et al., 2013; Kirkevåg et al, 2013), is basically a version of CAM5 (Liu et al., 2012) where schemes for aerosol chemistry, physics and interaction with clouds originally developed for CAM4-Oslo/NorEMS1 (is planned to) exist as options alongside with the modal aerosol modules (MAM3 and MAM7) of CAM5. At present, the aerosol coupling with ice nuclei is still as in CAM5 (coupled to MAM3), however, and the aerosol – cloud droplet coupling is still not fully consistent. This work is still in progress. Following Ghan (2013), ERF by anthropogenic (PD – PI) aerosols is split into a contribution by direct radiative forcing, a cloud radiative forcing contribution (containing both indirect and semi-direct effects), and a surface albedo forcing. These ERF's may further be split into short-wave and long-wave components. The preliminary results will be discussed and compared to published results from other models.

Knobelspiesse, Kirk

Progress in airborne polarimeter intercomparison for the NASA Aerosols-Clouds-Ecosystems (ACE) mission

The Aerosols-Clouds-Ecosystems (ACE) mission, recommended by the National Research Council's Decadal Survey, calls for a multi-angle, multi-spectral polarimeter devoted to observations of atmospheric aerosols and clouds. In preparation for ACE, NASA funds the deployment of airborne polarimeters, including the Airborne Multi-angle SpectroPolarimeter Imager (AirMSPI), the Passive Aerosol and Cloud Suite (PACS) and the Research Scanning Polarimeter (RSP). These instruments have been operated together on NASA's ER-2 high altitude aircraft as part of field campaigns such as the POlarimeter DEfinition EXperiment (PODEX) (California, early 2013) and Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys (SEAC4RS, California and Texas, summer 2013). Our role in these efforts has been to serve as an assessment team performing level 1 (calibrated radiance, polarization) and level 2 (retrieved geophysical parameter) instrument intercomparisons, and to promote unified and generalized calibration, uncertainty assessment and retrieval techniques. We will present our progress in this endeavor thus far and describe upcoming research in 2015.

Kristiansen, Nina

Measured and modelled aerosol lifetimes from Fukushima tracers

Measured and modelled accumulation-mode aerosol lifetimes are evaluated using radioactive isotopes released during the Fukushima Dai-Ichi nuclear power plant accident of March 2011. The radioactive isotope cesium (137Cs) released in large quantities during the accident attached to ambient accumulation mode aerosols (especially sulphate) and traced their fate in the atmosphere. Global measurements of the radioactive isotopes taken over several months after the release allow quantifying the measured lifetime of the carrier aerosols which are compared to aerosol lifetimes obtained by models. 19 atmospheric transport models simulate the transport of the radioactive isotopes using identical emissions. We investigate to what extent the models can reproduce the observations, especially with respect to the observed loss of aerosol mass with time. Model results sampled at exactly the same location and times as station measurements allow a direct comparison between measured and modelled aerosol decay and provide a strong constraint on modelled aerosol lifetime.

Kristjansson, Jon Egill

Climate Engineering and the Hydrological Cycle

Research on climate engineering (CE) is receiving growing attention, also among climate scientists (e.g.,

IPCC AR5), even though such research using Earth System Models (ESMs) raises a series of ethical questions that need to be considered. Also, any CE technique carries a risk of causing serious side effects, e.g., through disruptions of the hydrological cycle. Recently some robust results concerning precipitation changes in an engineered climate have emerged from multi-model ESM experiments within the Geoengineering Model Intercomparison Project (GeoMIP). We demonstrate how the changes in the hydrological cycle depend crucially on which Climate Engineering technique is applied. We show how that finding can be understood from atmospheric energy budget considerations. In particular, we show how cirrus cloud thinning, due to its targeting LW rather than SW radiation avoids some of the side effects that are characteristic of Solar Radiation Management techniques.

Kuehn, Thomas

Aerosol climate impact and its regional modulations in the 2000ies.

Apart from variations in solar irradiance and ocean temperature, increased anthropogenic aerosol emissions in South and East Asia have been suggested as possible causes for the hiatus in global warming during the last 15 years. While European and and North American aerosol emissions have continuously decreased since the 1980's, emissions in China and India have started increasing at the same time and, although total global aerosol emissions have decreased, aerosol effects on the global energy budget are expected to enhance towards the equator. In this study we used the aerosol-climate model ECHAM5-HAM2 to assess the effect that this re-distribution of anthropogenic aerosol emissions towards the equator (with all other anthropogenic influences kept fixed) between 1996 and 2010 may have on climate. Surprisingly we found that the cooling due the increased aerosol emissions in China and India is almost negligible compared to the warming caused by the decreasing aerosol emissions in Europe and North America. The effective radiative forcing (ERF; including aerosol indirect effects) was 0.42 W/m2 and the global equilibrium 2 m temperature increased by 0.25°C. The lack of cooling in China and India stems from a cancellation of sulphate cooling and BC warming, especially over China. There, the strong cloud cover leads to both attenuation of sulphate aerosol light scattering and saturation tendency of indirect aerosol effects on clouds. BC levels on the other hand increase also above the clouds (relative increase of BC levels is almost uniform with height), leading to warming through light absorption.

Levy, Rob

Creating a consistent dark-target aerosol optical depth record from MODIS and VIIRS

To answer fundamental questions about our changing climate, we must quantify how aerosols are changing over time. This is a global question that requires regional characterization, because in some places aerosols are increasing and in others they are decreasing. Although NASA’s Moderate resolution Imaging Spectrometer (MODIS) sensors have provided quantitative information about global aerosol optical depth (AOD) for more than a decade, the creation of an aerosol climate data record (CDR)

requires consistent multi-decadal data. With the Visible and Infrared Imaging Radiometer Suite (VIIRS) aboard Suomi-NPP, there is potential to continue the MODIS aerosol time series. Yet, since the operational VIIRS aerosol product is produced by a different algorithm, it is not suitable to continue MODIS to create an aerosol CDR. Therefore, we have applied the MODIS Dark-target (DT) algorithm to VIIRS observations, taking into account the slight differences in wavelengths, resolutions and geometries between the two sensors. More specifically, we applied the MODIS DT algorithm to a dataset known as the Intermediate File Format (IFF), created by the University of Wisconsin. The IFF is produced for both MODIS and VIIRS, with the idea that a single (MODIS-like or ML) algorithm can be run either dataset, which can in turn be compared to the MODIS Collection 6 (M6) retrieval that is run on standard MODIS data. After minimizing or characterizing remaining differences between ML on MODIS-IFF (or ML-M) and M6, we have performed apples-to-apples comparison between ML-M and ML on VIIRS IFF (ML-V). Examples of these comparisons include time series of monthly global mean, monthly and seasonal global maps at 1° resolution, and collocations as compared to AERONET. We concentrate on the overlapping period January 2013 through June 2014, and discuss some of the remaining discrepancies between the ML-V and ML-M datasets.

Liu, Xiaohong

AeroCom Inter-comparison of Aerosol Indirect Effect Through Cirrus (Ice) Clouds

Aerosol indirect effect (AIE) on climate remains one of the large uncertainties in the future climate change projection. Among various AIE mechanisms, aerosol indirect effect on cold cirrus (ice-AIE) has not been systematically assessed in previous IPCC reports. We proposed a set of sensitivity experiments for present and pre-industrial conditions to estimate the ice-AIE under AeroCom. In this presentation we report progress of this ice–AIE inter-comparison. We will highlight some results from several climate models from CAM5, CAM5-PNNL, ECHAM5, NASA GEOS-5 and CAM5-UMichigan. This inter-comparison of ice-AIE will be a useful contribution to the next IPCC assessment.

Lyapustin, Alexei

A New High-Resolution Aerosol Dataset from Algorithm MAIAC

Multi-Angle Implementation of Atmospheric Correction (MAIAC) is a new generation algorithm which uses time series analysis and processing of groups of pixels for advanced cloud detection and retrieval of aerosol and surface bidirectional reflectance properties. MAIAC makes aerosol retrievals from MODIS data at high 1km resolution providing information about the fine scale aerosol variability. This information is required in different applications such as urban air quality analysis, aerosol source identification etc. We will give an overview of MAIAC algorithm focusing on its aerosol typing capability which allows us to separate strong smoke/dust plumes from clouds and characterize their properties.

Mann, Graham

Pinatubo Emulation in Multiple Models (POEMs): planned co-ordinated experiments for the SPARC Stratospheric Sulphur and it's Role in Climate initiative (SSiRC)

The World Climate Research Program's SPARC initiative has a new international activity "Stratospheric Sulphur and its Role in Climate" (SSiRC) to better understand changes in stratospheric aerosol and precursor gaseous sulphur species. One component of SSiRC involves an intercomparison of a new generation of composition-climate models that simulate the stratospheric aerosol layer interactively (SA-CCMs). Three co-ordinated experiments have been designed which each of the participating SA-CCMs will carry out during 2014-2015. The first experiment is to characterise the volcanically quiescent stratospheric aerosol layer with simulations including only background sources of sulphur (e.g. from DMS and OCS) and only anthropogenic and passively degassing volcanic SO2 emissions. The 2nd experiment has the SA-CCMs running a 15-year transient stratospheric aerosol simulation through the 1998-2013 period with time-varying volcanic emissions. The experiment is to intercompare and evaluate how well the models capture the observed increase in stratospheric aerosol over the period (e.g. Hofmann et al., 2009; Vernier et al., 2011). The aerosol radiative forcing from the increased stratospheric aerosol offset about a quarter of the anthropogenic greenhouse gas radiative forcing over the same period (Solomon et al., 2011), and may have contributed to the recent "hiatus" in observed global warming. The third experiment of the SSiRC activity will be for each model to run a "perturbed physics ensemble" (PPE) of 5-year simulations through the Pinatubo period (1991 to 1995) with several uncertain parameters varied in each model. This presentation will focus on this third "PoEMS" experiment. Analysis of the Pinatubo PPE will use a powerful new technique to quantify and attribute sources of uncertainty in complex global models is described by Lee et al. (2011). This involves "conditioning" a Gaussian emulator to replicate (gridbox by gridbox) the results from an ensemble of runs with the full complex 3D model. Once trained on the ensemble, a Monte Carlo simulation with the fast emulator can be carried out for a full variance-based sensitivity analysis. For example, Carslaw et al., (2013, Nature) used the approach to quantify the uncertainty in indirect aerosol forcing from a 3D global chemistry-aerosol-microphysics model, decomposing the variance attributed to 28 uncertain emissions-types/processes-parameters/model-structures. Here the Gaussian emulation approach will be carried out on each model to characterize and inter-compare the magnitude and uncertainty of simulated stratospheric aerosol properties through the Pinatubo period and attribute the contributions of the uncertainty in radiative forcing.

Michou, Martine

Development and basic evaluation of a prognostic aerosol scheme in the CNRM Climate Model

We have implemented a prognostic aerosol scheme in the CNRM-GAME/CERFACS climate model, based upon the GEMS/MACC aerosol module of the ECMWF operational forecast model. This scheme describes the physical evolution of the five main types of aerosols, namely black carbon, organic matter, sulfate, desert dust and sea-salt. In this work, we describe the specificities of our implementation, for instance, taking into consideration a different dust scheme or boosting biomass

burning emissions by a factor of 2, as well as the evaluation performed on simulation outputs. The simulations consist of 2004 conditions and transient runs over the 1993-2012 period, and are either free-running or nudged towards the ERA-Interim Reanalysis. Evaluation data sets include several satellite instrument AOD products (i.e., MODIS Aqua classic and Deep-Blue products, MISR and CALIOP products), as well as ground-based AERONET data and the derived AERONET climatology, MAC-v1. The internal variability of the model has little impact on the seasonal climatology of the AODs of the various aerosols, and the characteristics of a nudged simulation reflect those of a free-running simulation. In contrast, the impact of the new dust scheme is large, with modelled dust AODs from simulations with the new dust scheme close to observations. Overall patterns and seasonal cycles of the total AOD are well depicted with, however, a systematic low bias over oceans. The comparison to the fractional MAC-v1 AOD climatology shows disagreements mostly over continents, while that to AERONET sites outlines the capability of the model to reproduce monthly climatologies under very diverse dominant aerosol types. Here again, underestimation of the total AOD appears in several cases, linked sometimes to insufficient efficiency of the aerosol transport away from the aerosol sources. Analysis of monthly time series at 166 AERONET sites shows, in general, correlation coefficients higher than 0.5 and lower model variance than observed. A large inter-annual variability can also be seen in the CALIOP vertical profiles over certain regions of the world. Overall, this prognostic aerosol scheme appears suitable for aerosol-climate studies. There is room, however, for implementing more complex parameterizations in relation to aerosols.

Mielonen, Tero

The inclusion of brown carbon aerosols in the ECHAM6-HAM aerosol-climate model

One of the key aspects in climate change is the effect of atmospheric aerosol particles on solar radiation. For black carbon (BC) and brown carbon (BrC), commonly referred as light-absorbing carbonaceous aerosols (LAC), the climate effects are complex. To estimate the overall climate effect of LAC, the level of aging and the distribution of LAC in horizontal and vertical have to be known. Currently, BC is included in most aerosol-climate models but only few models include BrC.
Recent studies indicate that BrC is emitted into the atmosphere from incomplete combustion. Furthermore, it is formed in the atmosphere as secondary organic aerosols. Consequently, the optical properties and the emissions of atmospheric BrC aerosols are not well known and their estimates have been based on theoretical studies and laboratory measurements. In order to have proper estimates on the climate effects of LAC, optical properties and emissions of BrC have to be modeled adequately.
In this work, we aim to produce new AERONET based estimates for BrC emissions. We use retrievals of BrC concentrations from AERONET inversion data to estimate the fraction of BrC emissions from the total organic carbon (OC) emissions. This is done using an iteration tool based on the Kalman filter. With this tool we optimize the BrC emission fractions for different emissions sources (biomass burning, fossil fuel, and biogenic emissions) in ECHAM6-HAM model. This optimization is made to produce the best match between modeled and AERONET retrieved BrC concentrations.

Munchak, Leigh

Global and regional validation of the Collection 6 MODIS dark target aerosol products, and comparison to Collection 5

The MODIS Collection 6 (C6) dark targets aerosol algorithms include several updates, including multiple wind speed look up tables over ocean and improved sensor calibration. We analyze the entirety of the MODIS-Aqua aerosol record against AERONET to characterize uncertainty in the products, and relate the new collection to the well-characterized Collection 5 (C5) products to understand specific improvements. Over land, ~70% of high quality AOD retrievals at 0.55 μm are within the C5 expected error bounds, which is comparable to C5; however, a slight overestimation of AOD at low optical depths and a slight underestimation at high optical depths that was observed in C5 has been eliminated in C6. The highest agreement with AERONET occurs in the Eastern U.S. and Europe. Regions with large surface reflectance, such as the Western U.S., or higher aerosol loading, including much of Africa and South America, remain a challenge. Over ocean, the inclusion of wind speed in the surface characterization has removed a wind speed dependant bias, and globally, ~63% of high quality AOD retrievals at 0.55 μm are within the C5 expected error bounds. The dust outflow regions off the coast of Africa show the poorest agreement with AERONET. The aerosol products validate acceptably for science, though users should be aware of some regional biases we present in this work.

John, Ogren

Climatology and Variability of Aerosol Properties from In-situ Monitoring Sites

In order to improve understanding of climate forcing by aerosols, the NOAA Earth System Research Laboratory (ESRL) and its collaborators (including both U.S. and foreign universities and science organizations and WMO/GAW) have developed a federated network of more than 20 sites measuring particle number concentration and aerosol optical properties (spectral aerosol light scattering, backscattering and absorption). The sites represent a variety of environmental regimes (e.g., polar, coastal, continental and mountain) and aerosol types (e.g., mineral dust, pollution, biomass burning, sea salt). The result is a long-term, cooperative program making atmospheric measurements that are directly comparable with all other stations in the network. Climatologies of aerosol properties measured by the NOAA federated network show that the annual median values of aerosol number concentration (CN), light scattering and light absorption span 3-4 orders of magnitude across all locations and vary by 1-2 orders within each regime. Median values of calculated parameters range from 0-2.5 for Ångström exponent, 0.78-0.98 for single scattering albedo and 0.1-0.15 for backscattering fraction. Despite the wide variation in amount and type of aerosol across the network, autocorrelation analysis suggests that the persistence of aerosol scattering is fairly consistent at most sites– the autocorrelation statistics r(k) for aerosol light scattering tend to be above 0.8 for lags of 3-5 h. The implication is that appropriate times scales of comparison with other measurements of aerosol loading (e.g., PM10, AOD) would be on the order of 3-5 h, while the corresponding length scales for comparison would be 60-100 km assuming an atmospheric transport speed of 20 km/h. Many of the

other aerosol properties investigated were slightly less persistent than aerosol scattering suggesting smaller time and length scales would be required to get good closure with other measurements. Strong diurnal oscillations in CN concentrations, indicative of new particle formation and/or diurnal source variations (e.g., upslope/downslope or onshore/offshore flow), were observed at all continental and mountain sites and at some coastal sites. In contrast, little to no diurnal structure was observed for the other aerosol properties at most sites. The aerosol observed at polar sites was the most persistent (e.g., autocorrelation remained high (>0.8) for longer lag times than observed at other site types). These statistical characteristics of aerosol variability can be used to evaluate the ability of forecast models to represent short-term aerosol variations, and can be used with global models to evaluate whether the parameterizations of fast processes leads to realistic variability in aerosol properties.

Perezga, Carlos

New Methods to Predict Regional Variations of the Mineral and Chemical Composition of Dust Aerosols

Soil dust aerosols in Earth system models are typically assumed to have globally uniform properties. However, regional variations of dust mineral and chemical composition are important for aerosol effects upon climate, including radiative forcing, deposition of bioavailable iron to the ocean, heterogeneous chemistry and ice nucleation. Regional variations in soil composition lead to variations in aerosol composition. Yet, deriving aerosol mineral content also requires knowledge of the parent soil size distribution along with the fragmentation of soil aggregates during the emission process. A challenge for modeling is that global atlases of soil texture and composition are based on wet sieving, a technique that breaks the aggregates, particularly phyllosilicates, that are encountered in natural soils, drastically altering the original size distribution of the soil that is subject to wind erosion. In the absence of knowledge about the undisturbed parent soil, previous studies generally have assumed that the emitted size distribution of each mineral closely resembles the wet-sieved size distribution. We propose both a semi-empirical and theoretical method to constrain the size-resolved mineral composition of emitted dust aerosols based on global atlases of soil texture and composition. Both methods re-aggregate clay phyllosilicate minerals into larger soil particle sizes. In our semi-empirical method we constrain the size distribution of each emitted mineral based on observed mineral distributions at the source. In our theoretical method, we reconstruct the undisturbed size distribution for each mineral as a function of soil texture and soil type and calculate the emitted size distribution using Kok's theory of brittle fragmentation. These approaches were tested within the NASA GISS Earth System ModelE. Dust aerosols are represented as an external mixture of minerals such as illite, kaolinite, smectite, carbonates, quartz, feldspar and gypsum, as well as iron oxides and accretions of iron oxides with each of these minerals. We also present a new publically available compilation of measurements of mineral fractions derived from ca. 50 references from the literature. This compilation is used to evaluate our new model of mineral and elemental composition within ModelE. We discuss the challenges of comparing simulated mineral fractions to measurements, which often come from field campaigns and ship cruises of limited duration. Despite uncertainties of the measurements, we show the importance

of estimating the undisturbed size distribution of the parent soil prior to wet sieving, along with the modification of this size distribution during emission. Our new model reproduces measurements showing greater amount of aerosols at silt sizes (whose diameters exceed 2 micrometers) including significant amounts of clay mineral aerosols (like illite) at silt sizes. Our model also reduces the systematic overestimation of quartz, while allowing iron to be transported farther from its source as impurities than in its pure, crystalline form. New Methods to Predict Regional Variations of the Mineral and Chemical Composition of Dust Aerosols Biomass

Petrenko, Maksym

Joint Accuracy Assessment of Aerosol Retrievals from Multiple Satellite Sensors and GEOS-5 model

Ground-based observations, particularly from the Aerosol Robotic Network (AERONET), play an important role in the validation and assessment of uncertainties present in satellite retrievals and model estimates of atmospheric aerosols over land and coastal locations. The recent addition of the Maritime Aerosol Network (MAN) to the array of the available AERONET products has enabled comparative studies of global aerosol products over oceanic and sea surfaces. We use AERONET and MAN data within the framework of the Multi-sensor Aerosol Products Sampling System (MAPSS) to examine the accuracy of aerosol retrievals from multiple spaceborne sensors, including MODIS (on Terra and Aqua), MISR, OMI, POLDER, CALIOP, SeaWiFS, and VIIRS, as well as the model-simulated aerosol fields from the MERRAero aerosol module of the GEOS-5 model. In this presentation, we will report our findings in analyzing the spatial and temporal distributions of the uncertainties in the global over-land and maritime retrievals of aerosols based on inter-comparing spaceborne and model-based data with coincident ground-based measurements from both AERONET and MAN.

Petrenko, Mariya

AeroCom Biomass Burning Emissions Experiment: update on the used method and status of the AeroCom effort

Biomass Burning (BB) emissions experiment, proposed to the AEROCOM community at the last year's (2013) annual meeting has received a warm welcome and engaged a significant number of participating models. This year, we will remind the group about the initial pilot study of comparing several BB emission datasets, and review the progress that has been made updating and testing the method of

using satellite-measured aerosol optical depth snapshots to constrain BB aerosol emissions in the global models. The global datasets of fire-and-smoke events, observed by MISR and MODIS during 2006, 2007 and 2008, to be used for model-satellite comparisons will also be described. These events were selected according to a number of criteria to be suitable for model-observation comparison at the scales of global model resolution. In addition, we will showcase preliminary results of model inter-comparisons within the BB experiment, outline plans for output analysis and summarize the expected results of this analysis.

Pitkanen, Mikko

Estimate of the radiative effect of brown carbon using AERONET products AeroCom

The AErosol RObotic NETwork (AERONET) provides aerosol size distributions and complex refractive index at four wavelengths (440, 675, 870, and 1020 nm). This information is used to retrieve the relative proportions of brown carbon BrC, black carbon BC, dust mineral and scattering host, separately for fine and coarse modes. The retrieval method is extended from Schuster et al. (JGR, 2005). The absorbing part of fine mode is initially assumed to consist of BC and BrC, but dust is added if necessary. Likewise, the absorbing coarse mode is initially assumed to consist of mineral dust, but BC and BrC are added if necessary. We estimated the direct radiative effect ADRE of BrC by using the volume fractions of BrC for all available AERONET sites. The effect of BrC at TOA was estimated as the difference between net fluxes for all aerosols and non-BrC aerosols using the radiative transfer package libRadtran. Non-sphericity of mineral dust was taken into account using the spheroid aerosol model by Dubovik et al. (JGR, 2006). The aerosol components retrieval from AERONET suggests that the highest amounts of brown carbon appear in locations close to intense aerosols sources eg. in China and India, but notably the fraction of BrC compared to other absorbing species (here BC and dust) can be comparably high at locations with lesser aerosol loading. According to our initial results the higher BrC content does not automatically translate into a significant BrC ADRE (all aerosols - non-BrC), but the presence of other absorbing species and the albedo also play a significant role. Annual BrC ADRE seems to vary from -0.8 W/m2 to 0.8 W/m2 and monthly averages can vary in a much larger range for locations with high BrC volume fraction and loading.

Povey, Adam

ORAC (the optimal retrieval of aerosol and cloud)

ORAC (the optimal retrieval of aerosol and cloud) is an open-source algorithm developed over the last decade to determine aerosol and cloud properties from multispectral imagery such as MODIS, AVHRR, ATSR, and SEVIRI to produce the GRAPE and GlobAerosol aerosol datasets. It uses an optimal estimation framework to fit the radiance in all channels simultaneously by varying the desired parameters, taking account of a priori information, and providing pixel-level error estimates on all retrieved quantities. Though simultaneous retrieval of aerosol and cloud properties is not possible, ORAC can retrieve both separately for measurements where unambiguous classification is not possible, allowing the data user to choose an appropriate means of discrimination. Through ESA's Climate Change Initiative (CCI), ORAC has undergone intense development over the last three years to improve the accuracy and consistency of both its aerosol and cloud retrievals. Results from the most recent round of validation for the ORAC products will be presented, comparing ORAC's retrievals across different sensors to independent products and model data, and showing a significant improvement in data quality. Additionally, the conclusions of a workshop on the determination of uncertainties in aerosol products organized by the Aerosol CCI project will be summarized.

Randles, Cynthia

The MERRAero Aerosol Reanalysis: Evaluation and Climate Study Applications

The Modern Era Retrospective-Analysis for Research and Applications (MERRA, Rienecker et al., 2011) is a NASA meteorological reanalysis (0.5° latitude × 0.625° longitude and 72 vertical layers up to ~80 km) over the EOS satellite era (2002 – present) using the Goddard Earth Observing System Data Assimilation System version 5 (GEOS-5). We have recently performed a companion aerosol reanalysis, MERRAero, using GEOS-5 in replay mode, where the MERRA analysis updates the atmospheric state every six hours while assimilation of aerosol optical depth (AOD) is performed. MERRAero includes GOCART aerosols (Chin et al., 2002), assimilation of bias corrected MODIS observations, and daily biomass burning emissions derived from MODIS Fire Radiative power estimates (Quick Fire Emission Dataset version 2/QFED2). Non-biomass burning carbonaceous aerosol emissions are from AeroCom, while anthropogenic sulfur dioxide emissions derive from the EDGAR inventory. Careful cloud screening and homogenization of the observing system input is required for aerosol data assimilation. This is accomplished by using a Neural Network scheme that translates cloud-cleared MODIS reflectance observations into AERONET calibrated AOD ("MODIS NNR"). Here we show an evaluation of MERRAero simulated AOD compared to independent retrievals from MISR and AERONET. It is important to note that, because only AOD is assimilated, the underlying GEOS-5/GOCART model determines both the aerosol vertical distribution and speciation (and thus absorption). Nevertheless, we show that the model generally does a good job simulating both aerosol absorption optical depth (AAOD) and aerosol index (AI) as compared to both OMI and AERONET, particularly when we make adjustments to assumed aerosol optical properties (Buchard et al., submitted to ACP). We also show relatively good agreement regarding aerosol vertical distribution compared to both CALIPSO and aircraft measurements. In the next iteration of MERRAero, which will be performed simultaneously with the upcoming MERRA-2 reanalysis, we will assimilate not only bias-corrected MODIS AOD, but also AOD from AERONET and MISR, the latter over bright surfaces only. We preview the effect of including these additional observing systems with a mini-reanalysis performed for the recent NASA SEAC4RS field campaign. Finally, we

compare present-day aerosol radiative forcing from MERRAero to recent observationally derived estimates. The MERRAero output products—including 3-dimensional (globally gridded) aerosol mass, optical properties, and aerosol radiative forcing—are available to researchers, such as modelers interested in using these present-day aerosol fields as inputs in climate response studies.

Redemann, Jens

A-Train aerosol observations – preliminary comparisons with AeroCom models and pathways to observationally based all-sky estimates of direct radiative forcing

We have developed a technique for combining CALIOP aerosol backscatter, MODIS spectral AOD (aerosol optical depth), and OMI AAOD (absorption aerosol optical depth) retrievals for the purpose of estimating full spectral sets of aerosol radiative properties, and ultimately for calculating the 3-D distribution of direct aerosol radiative forcing. We present results using one year of data collected in 2007 and show comparisons of the aerosol radiative property estimates to collocated AERONET retrievals. Use of the recently released MODIS Collection 6 data for aerosol optical depths derived with the dark target and deep blue algorithms has extended the coverage of the multi-sensor estimates towards higher latitudes. We compare the spatio-temporal distribution of our multi-sensor aerosol retrievals and calculations of seasonal clear-sky aerosol radiative forcing based on the aerosol retrievals to values derived from four models that participated in the latest AeroCom model intercomparison initiative. We find significant inter-model differences, in particular for the aerosol single scattering albedo, which can be evaluated using the multi-sensor A-Train retrievals. We discuss the major challenges that exist in extending our clear-sky results to all-sky conditions. On the basis of comparisons to suborbital measurements, we present some of the limitations of the MODIS and CALIOP retrievals in the presence of adjacent or underlying clouds. Strategies for meeting these challenges are discussed.

Robert, Charles

The stratospheric aspects the Aerosol_CCI project

In 2010, ESA started the Climate Change Initiative (CCI) as an element of their commitment to long-term provision of satellite observations. CCI includes 13 projects, each dedicated to one Essential Climate Variable (ECV). Amongst them, Aerosol_CCI covers the development of improved retrieval algorithms and datasets for the characterization of tropospheric and stratospheric aerosols.

Rumbolt, Steve

Ammonium Nitrate in UKESM1

Ammonium nitrate has been shown to be of increasing importance both in terms of radiative forcing of climate and air quality. A modal ammonium nitrate aerosol scheme is being incorporated into UKESM1 (the successor to HadGEM2-ES). Ammonium nitrate is provided by an extended version of GLOMAP-mode which uses a dissolution approach. This extension, in addition to providing nitrate, has wider implications for the operation of the code. The two major changes to the operation of GLOMAP are: 1) The ability to determine the gas-particle partitioning of semivolatile gases (including but not limited to ammonia and nitric acid). This includes a hybrid solver where an equilibrium approach is adopted for smaller particles but can also account for the larger particles that are out of equilibrium. 2) Components within each aerosol mode are considered in their ionic form if appropriate. e.g. “sea salt” is now a mixture of sodium, sulphate and chloride ions. This has implications for the radiation scheme in addition to GLOMAP. Here, initial results are presented from an atmosphere only model (HadGEM3) in preparation for inclusion into UKESM1.An update on OMI/TOMS retrieval aerosol products.

Sayer, Andrew

Recent progress in the NASA 'Deep Blue' aerosol retrieval algorithms

The 'Deep Blue' algorithms have been applied to retrieve aerosol properties from the SeaWiFS and MODIS satellite sensors. This presentation will cover recent updates to the algorithm, including the new MODIS 'Collection 6' dataset, and the in-development application to VIIRS.

Schulz, Michael

Aerosol Climatology from phase I and II

Schulz, Michael

AerChemMIP - planning experiments for CMIP6

Schuster, Greg

Understanding the absorption Angstrom exponent provided in the AERONET database

Recently, some authors have suggested that the absorption Angstrom exponent (AAE) can be used to deduce the component aerosol absorption optical depths (AAOD) of dust, brown carbon, and soot

carbon in the atmosphere. The premise behind this AAE approach is that AAE is a species-dependent aerosol property that does not depend upon particle size or mass, that absorbing aerosol species are externally mixed with one another, and that AAE is much less than 1 for black carbon. Other authors have found that AAE does not contain enough information to unambiguously speciate the absorbing aerosols. Thus, we explore this topic here, and point out some theoretical inconsistencies associated with using the AAE approach to deduce component AAODs from the AERONET retrievals. For instance, Level 2.0 retrievals at 15 West African sites subsampled for AAE < 1.0 indicate that 86% of the fine volume fractions are less than 0.2, 56% of the depolarization ratios are greater than 0.2, and 94% of the Angstrom exponents are less than 1.0. This indicates that most of the West African data with AAE < 1 are dominated by coarse mode dust, and that low AAE does not indicate pure BC, and that therefore AAE cannot be used to separate carbonaceous aerosols from dust. We obtained similar results at five Middle East dust sites subsampled for AAE < 1.0, with 59% of the fine volume fractions less than 0.2, 88% of the depolarization ratios greater than 0.2, and 73% of the Angstrom exponents less than 1.0. Additionally, we find that AAE << 1 is very unlikely to occur for size distributions with fine volume fractions greater than 0.5 at nine southern Africa and South America sites, unless the imaginary refractive index at the 440 nm wavelength is less than the imaginary refractive index at the red and near infrared wavelengths (i.e., k(440) < k(870)). Since black carbon has a spectrally invariant imaginary refractive index at these wavelengths, it is unlikely to be the cause of k(440) < k(870) and AAE < 1 when the fine mode dominates. We conclude that AAE < 1 is not caused by pure BC, and that the AAE approach cannot be used to separate carbonaceous aerosols from dust.

Schutgens, Nick

On the use of remote sensing observations for AEROCOM

We discuss strategies for evaluating aerosol models with remote sensing observations (MODIS, AERONET, Maritime Aerosol Network) that provide extensive global and temporal coverage and measure both extensive (AOT) as well as intensive aerosol properties (AE and SSA). Global models and observations differ strongly in their spatio-temporal sampling. Global model results are typical of large gridboxes (100 by 100 km), while observations are made over much smaller areas (10 by 10 km for MODIS, even smaller for AERONET and MAN). We study the spatial sampling issue using high resolution (10km) WRF-CHEM runs. Global model results are always available, albeit usually temporally averaged, in contrast to observations that are intermittent due to orbital constraints, retrieval limitations and instrument failure/maintenance. We study the temporal sampling issue using global models and observational sampling from actual remote sensing datasets. We find that differences in AOT due to sampling effects can be 100% for instantaneous values and can still be 40% for monthly or yearly averages. Such differences are comparable to or larger than typical retrieval errors in the observations. We propose strategies (temporal colocation, spatial aggregation) for reducing these sampling errors. We also evaluate one year of co-located AOT, AE and SSA from several AEROCOM models against MODIS, AERONET and MAN observations. Temporal colocation requires high frequency output (at least 6-hourly) which means that currently only a few AEROCOM models and a few experiments are suited for the evaluation that we propose. Preliminary results of this evaluation will be discussed.

Schwarz, Joshua

AeroCom suite performance on BC vertical profiles in source regions

Recent evaluations of AeroCom suite performance on BC vertical profiles via comparison to in situ measurements have focused primarily on the remote regions of the Pacific and Arctic, outflow from Asia, and North America (NA). Here we present proposed analysis meant to significantly expand NA comparisons and constrain performance in important, yet relatively untested, source regions in Europe and Africa. Single Particle Soot Photometer (SP2) data from the Deep Clouds Convection and Chemistry (DC3, 2012, NSF) and Studies of Emissions and Atmospheric Clouds Composition and Climate Coupling by Regional Surveys (SEAC4RS, 2013, NASA) in NA, the Contrail and Cirrus Experiment (CONCERT-2, 2011, DLR) and the Arctic Climate Change, Economy, and Society project (ACCESS-1, 2012, EU) in Europe, and the Saharan Aerosol Long-range Transport and Aerosol-Cloud-Interaction Experiment (SALTRACE, 2013, HGF/DLR) in the Cape Verde region and in the Caribbean will be used to these ends. We focus on specific features of the data set of interest in the comparison including possible high altitude biases, and biomass burning and dust emission dominated regions with relevance to optical remote sensing constrained evaluations of AeroCom performance.

Shi, Xiangjung

Estimating anthropogenic aerosol indirect effects of cirrus clouds using CAM5.1 with different ice nucleation parameterizations

The anthropogenic AIE through cirrus clouds is estimated by using different ice nucleation parameterizations in CAM5. Compared to Kärcher et al. (2006, hereafter KL) parameterization, Liu and Penner (2005, hereafter LP) and Barahona and Nenes (2009, hereafter BN) predict significantly larger AIE. Let $\eta\alpha$ denote the sensitivity of ice crystals number concentration (Ni) from homogeneous freezing to sulfate aerosol number concentration (Na). Following Kay and Wood 2008, $\eta\alpha$ is defined as: $\eta\alpha=d(\ln Ni)/d(\ln Na)$. Compared to the parcel model result, $\eta\alpha$ is underestimated in KL, but overestimated in LP and BN. This explains the differences between the estimated AIE through cirrus clouds by using different parameterizations. Aerosol indirect effects on cirrus clouds are complex. The changes in cirrus cloud properties might modulate atmospheric circulation and water vapor transfer, and then impact cloud forcing in other regions.

Shinozuka, Yohei

Aircraft- and ground-based assessment of relationships between CCN concentration and aerosol optical depth

Contrary to common assumptions in satellite-based analysis of aerosol-cloud interactions, $\partial \ln CCN/\partial \ln AOD$ is less than unity, i.e., the number concentration of cloud condensation nuclei (CCN)

less than doubles as aerosol optical depth (AOD) doubles. This is explained by condensation, coagulation and cloud processing that either drive particles from the Aitken mode to the accumulation mode or separate these two modes. This paper reports on the relationship in local air masses between CCN concentration, aerosol size distribution and light extinction observed during airborne field observations (e.g., ARCTAS, INTEX-B). The CCN-to-local-extinction ratio, when averaged over 1 km distance and sorted by the wavelength dependence of extinction, varies approximately by a factor of 2. This, together with uncertainties in aerosol hygroscopicity, vertical profile and AOD retrievals, challenges AOD-based CCN estimates. However, these large differences in estimated CCN may correspond to a considerably lower uncertainty in cloud drop number concentration (CDNC), given the sublinear response of CDNC to CCN. We discuss implications on the use of visible and near-infrared AOD from nadir-view passive satellite sensors.

Smirnov, Alexander

Version 3 AERONET processing – data product assessment for model validation and assimilation

The paper presents AERONET processing philosophy and modifications (Version 3). Data structure and cloud screening changes are presented. Update on columnar aerosol retrieval products is emphasized. Automatic Level 2 quality checks are discussed. New AERONET products are listed. Current status of AERONET components (MAN, SolRad-Net, Synergy tool) is shown.

Stier, Philip

Radiative forcing working group

A brief summary about the radiative forcing working group activities will be given.

Sundström, Anu-Maija

Decadal changes in CERES short wave clear-sky TOA fluxes; what can we say about aerosol contribution?

The changes in clear-sky short wave (SW) TOA fluxes is studied using ten years (Jan 2002-Dec 2011) of CERES data. The aim is to estimate the possible aerosol contribution to the TOA SW-flux changes. To asses this, AOD anomalies are defined from MODIS L3 data assimilation product as well as MISR data. The focus will be on areas where both MODIS and MISR show similar AOD anomalies (”present” - ”past”). Also changes in surface albedo and precipitable water were considered. Preliminary results

indicate that e.g. over Southern Europe and parts of North America a decrease in outgoing SW radiation at TOA for clear-sky is observed when comparing three year averages from 2009-2011 and 2002-2004 for the summer season (JJA). Over these areas both MODIS and MISR also show decreasing AOD. On the other hand, especially over North Eastern India during the dry season (DJF) an increase in AODs is observed, which is accompanied by increased SW cooling at TOA.

Takemura, Toshi

Relative contributions of regional emissions to the aerosol radiative forcing based on the AeroCom Phase III/HTAP2 Experiment

It is important to understand relative contributions of each regional and sector emission of aerosols and their precursor gases to the regional and global mean radiative forcing of aerosol-radiation and aerosol-cloud interactions. This is because it is useful for international cooperation on controls both of air pollution and anthropogenic climate change along most suitable reduction path of their emissions from each region and sector. The Task Force on Hemispheric Transport of Air Pollution (TF HTAP) under the United Nations researches the intercontinental transport of air pollutants including aerosols with strong support of the AeroCom initiative. The ongoing AeroCom Phase III/HTAP2 experiment assesses relative contributions of regional and sector sources of aerosols and their precursor gases to the air quality using global aerosol transport models with latest emission inventories. In this study, the extended analyses on the relative contributions of each regional and sector emission to the radiative forcing of aerosol-radiation and aerosol-cloud interactions are done from the AeroCom Phase III/HTAP2 experiment. Simulated results from MIROC-SPRINTARS and other some global aerosol models participating in AeroCom Phase III/HTAP2 experiment are assessed.

Thomas, Gareth

A posteriori discrimination of aerosol and cloud from satellite retrievals

The discrimination of cloudy and cloud free pixels is a key step in most satellite aerosol and cloud products and yet, despite the increasing sophistication and complexity of the underlying retrieval algorithms, the selection of either cloud free/cloudy pixels often relies on inherently subjective empirical tests. For both aerosol and cloud retrievals both false positive and false negative cloud detections can introduce large retrieval biases, which have a knock on effect when using such data for

long-term or regional/global study. In this presentation, a methodology for the determination of pixel type (water/ice cloud and aerosol type) using Bayesian analysis of the output of an optimal estimation cloud and aerosol retrieval (ORAC – the Optimal Retrieval of Aerosol and Cloud) will be presented. The approach uses the consistency of the fit provided by the optimal estimation retrieval, using a range of assumed aerosol and cloud types, to provide not only which type provides the best fit, but also a quantitative measure of confidence in this type selection.

Torres, Omar

Assessment of OMI decadal record on aerosol absorption

A unique decadal record of aerosol absorption optical depth and single scattering albedo from near UV observations has been produced from OMI observations. The OMI aerosol absorption record has been assessed by comparison to AERONET and SKYNET measurements of aerosol optical depth (AOD) and single scattering albedo (SSA) retrievals. Ground-based and satellite-borne observations were inter-compared using standard statistical analyses of temporal and spatially collocated individual measurements. Monthly mean values of AOD and SSA of both AERONET and OMI measurements over the ten-year record were also analyzed. Both analyses indicate a high level of consistency between the two data sets. The evaluation at the monthly-mean level, however, shows that the noise associated with individual retrievals averages out, resulting in improved statistical measures of the comparison. A detailed discussion of the evaluation of the OMI long-term aerosol record will be presented.

van Weele, Michiel

Clear-sky and all-sky direct forcing estimates based on TM5 and a doubling-adding radiative transfer model using observed clouds

Uncertainties in the direct radiative forcing of aerosols can be calculated as the square root sum of uncertainties in (1) aerosol load, e.g. related to emissions and residence times, (2) mass extinction coefficient, e.g. related to water uptake, and (3) radiative forcing efficiency (E), i.e. the normalized radiative forcing with respect to AOD (Myhre et al., 2013). Cloud effects constitute a major source of uncertainty w.r.t. the radiative forcing efficiency. In this work we provide an independent estimate on the impact of clouds on E using the global chemistry-transport model TM5 Aerocom Phase-2 simulations in combination with FRESCO cloud fraction and scattering layer heights from SCIAMACHY and climatological surface albedo observations. Shortwave radiative transfer is calculated with a broadband version of the Doubling-Adding KNMI (DAK) model using 16 streams and 29 wavelength bands. TM5 simulations have been performed for the year 2006 with and without aerosols and using pre-industrial (1850) aerosol (precursor) emissions. Results will be shown of the present-day direct radiative effect and of the ratio of all-sky to clear-sky radiative forcings of the anthropogenic component at the surface and top of atmosphere. Comparisons will be made with other estimates of the cloud effects on E and key uncertainties are discussed including the role of the simulated aerosol vertical profiles and the applied spectral surface albedo.

Ventress, Lucy (via A.Povey)

Validation of retrieved volcanic ash properties from the Infrared Atmospheric Sounding Interferometer (IASI)

Interest in the ability to detect and characterize volcanic ash plumes has increased following the eruption of Eyjafjallajökull. The Infrared Atmospheric Sounding Interferometer (IASI), on board both the MetOp-A and MetOp-B platforms, is a Fourier transform spectrometer covering the mid-infrared (IR) from 645-2760cm^{-1} (3.62-15.5µm) with a spectral resolution of 0.5cm^{-1} (apodized) and a pixel diameter at nadir of 12km. These characteristics allow global coverage to be achieved twice daily for each instrument and make IASI a very useful tool for the observation of larger aerosol particles (such as desert dust and volcanic ash) and the tracking of volcanic plumes. The thermal infrared spectra shows a rapid variation with wavelength due to absorption lines from atmospheric and volcanic gases as well as broad scale features principally due to particulate absorption. The ash signature depends upon both, the composition and size distribution of ash particles as well as the altitude of the volcanic plume. To retrieve the properties of ash plumes, IASI brightness temperature spectra are analyzed using an optimal estimation retrieval scheme and a forward model based on RTTOV. Initially, IASI pixels are flagged for the presence of volcanic ash using a linear retrieval detection method based on departures from a background state. Given a positive ash signal, the RTTOV output for a clean atmosphere (containing atmospheric gases but no cloud or aerosol/ash) is combined with an ash/cloud layer using the same scheme as for the Oxford-RAL Retrieval of Aerosol and Cloud (ORAC) algorithm. The retrieved parameters are ash optical depth (at a reference wavelength of 550nm), ash effective radius, layer altitude and surface temperature. Here we present results for the Eyjafjallajökull and Grimsvötn eruptions, along with a method of validating the retrieved plume altitude using the CALIOP instrument.

Wang, Rong

Reducing uncertainty in black-carbon climate forcing using a new inventory and high-resolution model

Black carbon (BC) is the most important short-lived climate forcer with significant impacts on both climate and health. However, the radiative forcing (RF) of BC is subject to a wide uncertainty, largely due to the limitations that models have to capture the observed light absorption. In this study, we investigated the effect of using highly disaggregated inventory and high-resolution model on modelling of BC. It's found that low resolution in emissions and models is a significant and overlooked source of error in previous studies. Using a detailed 10-km emission inventory and a 50-km atmospheric model allows us to reduce the under-estimation of BC absorption by more than 50% over Asia. Further downscaling the BC field to 10 km reduces the bias to –5% in Asia. The underestimation of coarse-resolution models can be attributed to the fact that about half of the observational sites are located in locations within the top 90th percentile of BC AAOD. To reinforce these results, we applied a Bayesian

method and obtain a best estimate of 0.37 Wm-2, with a 90% uncertainty range of 0.11-0.83 W m-2. Our best estimate is lower than previously thought, while the uncertainty is reduced by 40%, essentially due to a higher resolution used. This lower but concentrated RF of BC implies that reducing BC emissions will improve air quality but bring less co-benefits for climate than expected.

Winker, David

Retrievals and Validation of Above-Cloud Aerosol Properties

The CALIOP lidar, flying on the CALIPSO satellite, offers many new capabilities for observing and retrieving aerosol. Recently, we have applied a new constrained retrieval technique to CALIOP Level 1 profiles to retrieve properties of smoke and dust above opaque water clouds in two regions of the Atlantic Ocean. The results have been used to characterize aerosol optical properties and to validate the standard CALIOP aerosol products. In the future we hope to extend this analysis to other regions.

Xi, Xin

Top-down estimates of SO2 degassing volcano emissions using in situ SO2 measurements and the WRF-STILT model, a case study at the Turrialba Volcano

Continuous volcanic degassing emissions are an important natural source of sulfur-rich gases and aerosols in the lower troposphere. The Aerosol Comparisons between Observations and Models hindcast emission dataset (AEROCOM-II HCA0 v1, 1979−2007) assumes a fixed extra-eruptive SO2 degassing rate of 6.2×10-4 kt/day for ~807 volcanoes around the world. This constant flux estimate does not account for the heterogeneity in the magmatic-hydrothermal processes of different volcanoes, and may cause biased representations of volcanic degassing on the natural background SO2 concentrations at local, regional and global scales. This motivates us to apply inverse modeling techniques to improve the estimate of SO2 degassing emission rates using in situ SO2 measurements and a Lagrangian back-trajectory model. Here we present a case study at the Turrialba Volcano (10.025°N, 83.767°W) using SO2 measurements from unmanned aerial systems (UASs) during March 2013 and the WRF-STILT model. The model-simulated atmospheric trajectories and surface influence are used with the AEROCOM a priori SO2 emission dataset to predict the SO2 concentrations along the UASs' flight paths. The model predictions are then compared against the measurements in a statistical procedure to minimize the model-data difference thereby yielding improved posterior estimates of volcanic SO2 degassing emission rates. Further, the derived top-down SO2 emission fluxes will be implemented in the global/regional GEOS-Chem model to evaluate the impact on atmospheric composition focusing on the differences between the baseline and top-down GEOS-Chem simulations. The study will act as a proof of concept and will evaluate the applicability of top-down SO2 degassing rates in global chemical transport models. This method could potentially be expanded globally using global archives of volcanic SO2 measurements, such as the WOVO dataset (http://www.wovodat.org).

Xue, Yong

A Consistent Aerosol Optical Depth (AOD) Dataset over China

The objective of this study is to merge multiple satellite AOD products to obtain a new consistent AOD dataset. For this purpose, five satellite AOD products are chosen as the source AOD maps, including three MODIS AOD products (version Collection 051 MODIS-DT and MODIS-DB AOD product, China collection 2.0 AOD dataset), one SeaWiFS AOD product and one MISR AOD product. Because each source AOD products may have different biases for different surface albedo and AOD values, the biases and fusion weights were computed for different ranges of surface albedo and AOD values separately. Using the weight result, fused AOD dataset is produced based on maximum likelihood estimate (MLE) algorithm. The fused AOD dataset has been validated using AOD data from China Aerosol Remote Sensing Network (CARSNET) and Aerosol Robotic NETwork (AERONET). The new AOD dataset show significant improvement on the correlation with the AERONET and CARSNET derived AOD data with good accuracy. Compared with AERONET AOD data, the correlation coefficient (R) of fused AOD dataset increased to 0.92 from 0.78 (MODIS-DB), 0.85 (SRAP), 0.88 (MISR), 0.88 (SeaWiFS) AOD products. The root mean square error (RMSE) of fused AOD dataset is 0.18, which is nearly equal to MODIS-DT (RMSE=0.18), SRAP (RMSE=0.16) and SeaWiFS (RMSE=0.17) AOD products but much smaller than MODIS-DB (RMSE=0.42) AOD product. Compared with CARSNET AOD data, the correlation coefficient R of fused AOD dataset increased to 0.94 from 0.75 (SeaWiFS), 0.87 (MODIS-DB), 0.87 (SRAP), 0.87 (MISR) AOD product. The RMSE of fused AOD dataset is 0.16, which is smaller than MODIS-DT (RMSE=0.18), SRAP (RMSE=0.17) and SeaWiFS (RMSE=0.18) AOD products and much smaller than MODIS-DB (RMSE=0.37) AOD product.

Yu, Fangqun

Seasonal variations of new particle formation at Storm Peak Laboratory: Key parameters controlling atmospheric nucleation and global implications

A clear understanding of new particle formation (NPF) mechanisms is critical for assessing aerosol indirect radiative forcing and associated climate feedback processes. NPF has been observed frequently at Storm Peak Laboratory (SPL), a high elevation mountain-top observatory in Colorado. Detailed analysis of field measurements taken in March and July of 2012 at SPL reveals significant and interesting differences in NPF during the spring and summer months. Persistent long-lasting NPF occurred on a daily basis in March but was absent in July. Bursts of ultrafine particles did occur frequently in July but such bursts were short-lasting and didn't show any obvious pattern. A global chemical transport model (GEOS-Chem) coupled with a size-resolved advanced particle microphysics (APM) model are used to interpret in-depth this observed nucleation phenomena. Model simulations indicate that aerosol precursors were dominated by H2SO4 gas in March and by low volatile secondary

organic gases (LV-SOGs) in July, which is consistent with previous particle composition measurements at SPL. The observed persistent daily NPF in March and the absence of regional-scale nucleation in July at SPL indicate that H2SO4 gas plays a much more critical role in the initial nucleation process, although LV-SOGs dominate particle growth in July. We carried out simulations using two different nucleation schemes: (1) ion-mediated nucleation (IMN) of H2SO4-H2O and (2) a parameterization of H2SO4-LV-SOGs nucleation derived from recent CERN CLOUD experiments. The simulations based on the IMN scheme capture well the observed persistent daily nucleation events in March and the absence of regional scale NPF in July while those based on the H2SO4-LV-SOGs nucleation parameterization substantially over-predict the NPF and aerosol number concentrations at SPL in July. The global implications of the two different nucleation schemes will be discussed.

Yu, Pengfei

Aerosol Composition, Size Distribution and Optical Properties Simulated by a Sectional Aerosol

A sectional microphysics model (CARMA) coupled with CAM5-Chem is used to study the aerosol composition, size distribution, vertical distribution and optical properties. We compare the simulations with multiple datasets including satellites, ground observations and airborne missions including the data from recent SEAC4RS campaign (Studies of Emissions and Atmospheric Composition, Clouds and Climate Coupling by Regional Surveys, Aug-Sep, 2013). Our simulations are within the observational error bars for the mass of organics, sulfate and black carbon from the boundary layer to upper-troposphere. CARMA, as a sectional model, provides detailed aerosol size distributions from nano-meters to tens of microns, which is important to determine optical properties. We investigate how the aerosol size distribution varies with altitude with and without fire events. Modeled spatial gradients of [O]:[C] and [OC]:[SO4-2] ratios are compared with the observation datasets collected over forests, fires and cities. These ratios are important to constrain the budget of secondary organic aerosols. We will discuss the values of these ratios over the U.S. and the globe.

Zhang, Hua

Improvements of cloud microphysics in the aerosol-climate model BCC_AGCM 2.0.1_CUACE/Aero: evaluation against observations, and updated aerosol indirect effects

A two-moment cloud microphysical scheme, to predict both the mass and number concentrations of cloud droplets and ice crystals, is implemented into the aerosol-climate model BCC_AGCM2.0.1_CUACE/Aero. The model results for aerosols, cloud properties, and meteorological fields are evaluated, and the anthropogenic aerosol indirect effect (AIE) is estimated. The new model

simulates more realistic aerosol mass concentrations and optical depth compared with the original version using a one-moment bulk cloud microphysical scheme. The global annual mean column cloud droplet number concentration (CDNC) from the new model is 3.3×10^{10} m-2, which is comparable to the 4.0×10^{10} m-2 from satellite retrieval. The global annual mean cloud droplet effective radius at the cloud top from the new model is 8.1 μm, which is smaller than the 10.5 μm from observations. The simulated liquid water path (LWP) in the new model is significantly lower than that in the original model. In particular, the annual mean LWP is lower in the new model by more than 100 g m-2 in some mid-latitude regions, and hence much more consistent with satellite retrievals. Cloud radiative forcing and precipitation are improved to some extent in the new model. The global annual mean radiation budget at the top of the atmosphere is -0.6 W m-2, which is considerably different from the value of 1.8 W m-2 in the original model. The global annual mean anthropogenic AIE is estimated to be -1.9 W m-2 without imposing a lower bound of CDNC, whereas it is reduced significantly when a higher lower bound of CDNC is prescribed.

Zhang, Jiachen

Investigating the Vertical Distribution and Source Attribution of Black Carbon over the Pacific Ocean

Long-range transport of black carbon (BC) aerosols to the Pacific Ocean can potentially play a significant role in changing the marine climate through influences on temperature and cloud profiles and the top-of-atmosphere and surface energy balance. Therefore, quantitatively understanding sources of BC over the Pacific, particularly at different altitudes, is of great importance. In this study, we simulate the transport of thirteen continental BC tracers with a variety of e-folding aging times (few hours to 1 month) using the global chemical transport model MOZART-4. We then optimize BC aging rate according to different source regions by constraining the vertical profile of BC concentrations to the HAIPER Polo-to-Pole Observations (HIPPO). We find that for all HIPPO deployments, a shorter BC aging timescale (less than half day) for tropical and mid-latitude tracers and a longer aging timescale (2-10 days) for high-latitude tracers (except summer) in most cases significantly reduces model biases. By comparing the source-receptor relationship between the optimized BC tracers over the Pacific, we find that during 2009-2011, East Asia contributes most to the BC loading over the Northern Pacific in all seasons except summer, while South American, African and Australian tracers dominate the BC loadings over the Southern Pacific. In addition, unlike other tracers, African BC is a dominant contributor over a larger area in the free troposphere versus the boundary layer. Our findings indicate that the aging rate of BC strongly depends on source location and season, which may significantly influence the contribution of different source regions to BC forcing over the Pacific Ocean.

Zhang, Zhibo

Shortwave Direct Radiative Effects of ‘above cloud’ Aerosols over oceans derived from 6 years of CALIOP and MODIS observations

The shortwave direct radiative effect (DRE) of aerosols at TOA is strongly dependent on the underlying surface. Over dark surfaces, the scattering effect of aerosols is generally dominant, leading to negative DRE (i.e., cooling) at TOA In contrast, when light- absorbing aerosols reside above clouds, aerosol absorption is significantly amplified by cloud or surface reflection, which offsets or even exceeds the scattering effect of the aerosol leading to a less negative or even positive (i.e., warming) TOA DRE. Therefore, in order to understand the full complexity of aerosol radiative effects on climate, it is important to quantify the DRE under both clear-sky and cloudy-sky conditions. Based on 6 years of collocated CALIOP and MODIS (Moderate Resolution Imaging Spectroradiometer) observations, we investigated the shortwave direct radiative effect (DRE) of aerosols overlying low-level liquid phase clouds over global oceans. We noted that the occurrence frequency of ACA has strong geographical and seasonal variations. Using 6 years of collocated CALIOP and MODIS data, and a novel method recently developed in (Zhang et al., 2014), we computed the DRE of ACA over global oceans. We found that ACA has a strong positive DRE over the south-east Atlantic region where absorbing smoke and polluted dusts are often observed overlying highly-reflective stratocumulus clouds. In contrast, the DRE is negative over the north-east Atlantic region where dusts are often found over broken cumulus clouds. We also carried out a comprehensive analysis of the impact of various uncertainty sources, including CALIOP and MODIS retrieval uncertainties, cloud diurnal variations and aerosol model assumption, on ACA DRE. The results from this study will be used in future research to constrain the ACA DRE in climate models.