ABSTRACTS

of presentations during the combined

14th AeroCom

3rd AeroSAT and

1st AerChemMIP workshops

October 5 – October 9, 2015

ESA - ESRIN, Frascati, Italy

in alphabetical order by presenter

ORAL title

POSTER title

B.Andrews

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

In the spring of 2015 AeroCom initiated a project comparing model output to in-situ, surface-based measurements of aerosol optical properties. The model/measurement comparison project, called INSITU, aims to evaluate the performance of a suite of AeroCom aerosol models with observations from the approximately 70 surface sites which have submitted their data to the World Data Centre for Aerosols (http://ebas.nilu.no/). The INSITU project is intended to look at how well models reproduce (i) aerosol climatologies on a variety of time scales; (ii) aerosol characteristics and behaviors (e.g., aerosol persistence and the systematic relationships between aerosol optical properties); and (iii) aerosol trends. Though INSITU is a multi-year endeavor, preliminary phases of the analysis suggest substantial model biases in absorption and scattering coefficients compared to surface measurements, though the sign and magnitude of the bias varies with location. Spatial patterns in the biases highlight model weaknesses, for example: the inability of models to properly simulate aerosol characteristics at sites with complex topography. Additionally, differences in modeled and measured systematic variability of aerosol optical properties suggest that some models are not accurately capturing specific aerosol behaviors (e.g., the tendency of in-situ surface-measured single scattering albedo to decrease with decreasing aerosol extinction coefficient). The hope is that these analyses will inform iterative improvements to model aerosol modules.

K.Aoki

Validation plan of GCOM-C1/SGLI satellite aerosol optical properties retrievals from ground-based and ship-borne sky radiometer

We provide the information, in this presentation, on the aerosol and cloud optical properties with respect to their temporal and spatial variability in the world. The global distributions of aerosols have been derived from earth observation satellite (ex. The GCOM-C1 satellite scheduled to be launched in JFY 2016), and have been simulated in numerical model (ex. SPRINTARS), which assume optical parameters. However, these distributions are difficult to derive because of variability in time and space. Therefore, aerosol optical properties were investigated using the measurements from ground-based and ship-borne sky radiometer (POM-01, & -02: Prede Co. Ltd., Tokyo, Japan). Sky radiometer has become a useful tool for aerosol and cloud observations. The obtained aerosol optical properties (Aerosol optical thickness, Ångström exponent, Single scattering albedo, and etc.) and size distribution volume clearly showed spatial and temporal variability. In this presentation, we present the temporal and spatial variability of aerosol optical properties at each site and validation plan of GCOM-C1 satellite programs.

Y.Balkanski, L. Menut, S. Jourdain, E. Garnier, C. Eschstruth, M. Vrac, R. Vautard and P. Yiou

Simulation of the Laki volcano based upon analogs of winds

We used daily surface pressure measurements from 1783 over Europe to reconstruct a year of 3D wind fields based upon the closest analog found in the 6-hourly fields from the ECMWF ERAI re-analysis from 1979 to 2013. These fields are then used to nudge the LMDZORINCA global model with a full chemical scheme and a horizontal resolution of 1.29°x0.94° with 39 vertical layers to simulate the emissions of SO2 from the volcano emitting over several months from June to August 1783. Fields of SO2 and H2SO4 were analyzed over the whole year of 1783. We inject 81 Tg (S) over the period. In France, the Royal society of medicine had developed for the first time a network of persons that observed both climatic variables and morbidity. The network is composed of 150 contributors over France, and has a more scattered coverage for Italy, Austria, Germany the United States and Madagascar. The measurements reported three times a day include: temperature, air pressure, air humidity wind direction and a description of the sky. Within the CHEDAR (Climate and Health Data Rescue and Modelling) project an archive of daily observations of fogs over French meteorological stations was created and registers of deaths in main cities were compiled. These data indicate that increased mortality occurred from June to September 1783 immediately following the Laki eruption when compared to the average mortality over the period from 1774 to 1789. We quantified this increase over 23 cities in France. We provide a comparison of SO2 surface concentrations and draw the following conclusions:
- The days when the first manifestations of the volcano are reported over Western and Northern Europe are extremely well captured by the construction of analogs of winds for 1783.
- The sharp increase and the days of heavy fogs are correlated with decreases in visibility due to the advection of sulfur from the volcanic cloud
- Increased mortality in the 4 months that followed the eruption coincides with large concentration increases in SO2 and H2SO4.

H.Bian, M. Chin, M. Schulz, D. Hauglustaine, G. Myhre, S. Bauer, R.B. Skeie, K. Sudo and K. Tsigaridis

AeroCom Phase III Nitrate model experiment: preliminary analysis

Nitrate is an important aerosol component and impacts on atmospheric chemistry, radiative forcing, and ecosystem. A systematic multi-model experiment on the physical and chemical formation/loss processes for the atmospheric nitrate was proposed as a part of the AeroCom III study. In this talk, we will present a preliminary analysis of multi-model nitrate simulations and evaluate the results with various measurements from surface stations and aircraft measurements. Such an analysis not only reveals diversity of nitrate simulation among the AeroCom models, but also helps us understand the reasons causing the diversity.

K.Bollasina

The Atmospheric Circulation as a Key Mediator of Aerosol-driven Climate Impact

Over highly polluted regions, aerosol forcing can be an order of magnitude larger than that of greenhouse gases, as is the case of the Asian haze. Asia has the world's highest aerosol loading as emissions of aerosols and their precursors have dramatically increased in the past decades due to rapid urbanization and population growth. By modulating radiation in the atmosphere through scattering and absorption, and by altering cloud properties, aerosols affect surface and atmospheric heating gradients and precipitation distribution, which in turn lead to changes in the atmospheric circulation. This has the potential to affect climate across the planet, also through changes in the extensive Asian monsoon, one of the key features of the global atmospheric circulation. Not only the mechanisms underpinning regional aerosol forcing over Asia are uncertain, but also the potentially important feedbacks between aerosols, atmospheric dynamics and the hydrological cycle are unknown and, often, neglected.
A putative objective of climate model evaluation is the reduction in uncertainty of climate model projections. However, the relationship between historic and present-day model performance and

K.Bowman

Emergent constraints in chemistry-climate interactions

A putative objective of climate model evaluation is the reduction in uncertainty of climate model projections. However, the relationship between historic and present-day model performance and future model response is not straight-forward. However, emergent constraints are a relatively new methodology that exploits correlations between present day performance of a climate model ensemble and the future response of that ensemble under climate forcing. We discuss this methodology and how it has been applied to diverse areas including atmospheric hydrology and carbon cycle science. We then explore how observations of ozone and it radiative effect from the NASA Tropospheric Emission Spectrometer (TES) could be used within an emergent constraint approach as applied to the Atmospheric Chemistry Climate Model Intercomparison (ACCMIP) and the Chemistry Climate Model Initiative (CCMI) ensembles. We show that there are emergent constraints for ozone radiative forcing for ACCMIP; however, these constraints are dependent on the ensemble and the observing system.

K.Carslaw

A statistical approach to quantifying and constraining model uncertainty

We are proposing a new AeroCom initiative to explore the parametric uncertainty in multiple global aerosol models, which will be the first time any global modelling community has attempted such a

coordinated comprehensive approach to understanding model uncertainty. In this presentation we show how perturbed parameter ensembles and statistical analysis can be used to explore the magnitude and causes of uncertainty in aerosols and radiative forcing in a single model. In Carslaw et al. (2013, Large contribution of natural aerosols to uncertainty in indirect forcing) we analysed the uncertainty in global mean aerosol-cloud forcing between the pre-industrial and present day. Here we will show an extension of these results to regional forcing and to forcings over more recent decades. The results show that the leading causes of uncertainty in global mean forcing are very different over recent decades compared to forcings since the pre-industrial. In particular, natural aerosols are much less important. However, on regional scales natural emissions can still be an important cause of uncertainty. In Regayre et al. (GRL, 10.1002/2014GL062029), we hypothesised that the uncertainty in the near-zero global mean forcing between 1978 and 2008 may be dominated by the extent to which positive and negative regional forcings cancel, which is likely to vary across multiple models. Thus, analysis of global mean forcing uncertainty may be misleading and inappropriate. This could be explored in a multi-model uncertainty study. We also show how aerosol observations might be used to narrow the forcing uncertainty range. The spread of aerosol predictions is quite large, with many simulations lying outside the range of observations. In principle it ought to be possible to eliminate these results and thereby narrow the forcing uncertainty range. However, we show that a reduction in uncertainty in aerosol properties doesn't translate into a large reduction in forcing uncertainty. The results are important for how we relate "model skill" against observations to our confidence in the ability of the model to calculate forcing. Again, this is something that could be further explored in a multi-model uncertainty analysis.

H.Chen, Z.Wang and J. Li

A Global Nested Atmospheric Chemical Transport Model (GNAQPMS): Development and Evaluation

GNAQPMS is a global nested atmospheric chemical transport model, based on the Nested Air Quality Prediction Modeling System (NAQPMS) and the Global Environmental Atmospheric Transport Model (GEATM), developed at the Institute of Atmospheric Physics, Chinese Academy of Sciences. As a multi-scale nested model, GNAQPMS can simulate the transportation and formulation of primary and secondary pollutants from global to urban scale. It includes advection, diffusion and convection processes, gas/aqueous/aerosol chemistry, and modules of dry/wet deposition. The main features of GNAQPMS include: 1) high resolution, 2) nested from global to regional and urban scale, 3) coupled Hg chemistry and deposition module, 4) coupled tracer-tagging module. Comparisons between the simulated results and ozone observations (including surface and ozonesonde observations) show that the model is capable to reproduce the spatial, temporal and vertical variation of global ozone concentrations. And it was demonstrated that the nested method could improve ozone simulation over East Asia compared to the global simulation. At present, we are working on coupling the GNAQPMS model to the earth system model of the Chinese Academy of Sciences (CAS-ESM) as the chemical component. And the simulations of global aerosol compositions are under evaluation. The details will show in the presentation.

M.Chin

Results for AeroCom III/HTAP2 model experiments

HTAP2 model experiment and analysis: We will present the results of the UN TF HTAP phase 2 model experiments. The BASE simulations of AOD and AAOD will be compared with remote sensing data from the space-borne and ground-based instruments, and the surface concentrations will be compared with the measurements. The influence of long-range transport and the source-receptor relationships will be presented from the "tagged region" model experiments. Issues and next steps will be discussed.

Proposal of UTLS aerosol analysis

Proposed analysis/model experiments – Volcanic and anthropogenic contributions to the UTLS aerosol loading and trends: This topic is related to the SSiRC and CMIP6 model experiments, as well as a good comprehensive study for the atmospheric sulfur cycle. Results can also be analyzed for assessing the role of monsoon transport. I can show the GOCART model simulations, as an example, of UTLS aerosols and compare them with the OSIRIS and SCIAMACHY satellite observations in the LS and the CARIBIC aircraft data in the UT.

M.Christensen

New Product to Assess Aerosol-Cloud Interactions Using ORAC (A)ATSR data

Aerosols play a significant role in Earth's climate by scattering and absorbing incoming sunlight and affecting the formation and radiative properties of clouds. The extent to which aerosols affect cloud remains one of the largest sources of uncertainty amongst all influences on climate change. Now, a new comprehensive dataset has been developed under the ESA Climate Change Initiative (CCI) programme to quantify how changes in aerosol levels affect these clouds. The unique dataset is constructed from the Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm used in (A)ATSR retrievals of aerosols generated in the Aerosol CCI and the CC4CL (Community Code for CLimate) for cloud retrieval in the Cloud CCI. These state-of-the-art retrievals are merged together to quantify the susceptibility of cloud properties to changes in aerosol concentration. Aerosol-cloud susceptibilities are calculated from several thousand samples over 1x1 degree globally gridded regions. Two-dimensional histograms of aerosol and cloud properties are also included to facilitate seamless comparison between other satellite and modelling data sets. Initial comparisons between the new ORAC product and ECHAM6 model data reveal that the global aerosol indirect radiative effect still remains overly exaggerated in current model simulations of warm low-level clouds.

P.Colarco

Diversity of Aerosol Simulations in the NASA GEOS-5 Model: Impacts of Meteorology and Spatial Resolution

Uncertainties in aerosol distributions, properties, and processes allow for a wide diversity of aerosol representations in global models, which complicates the attribution of simulated climate change, for example, to specific forcing agents. A component of model diversity results from fundamental unknowns in critical aerosol parameters, such as optical properties. Other components of model diversity, however, arise from structural considerations of the models themselves, for instance, spatial resolution and basic model physics. We investigate these sources of diversity using different instances of the NASA Goddard Earth Observing System version 5 (GEOS-5) Earth system model. GEOS-5 runs the Goddard Chemistry, Aerosol, Radiation, and Transport (GOCART) aerosol module online and radiatively coupled within its atmospheric general circulation model. Two specific structural considerations are addressed: horizontal spatial resolution and driving meteorology. For all cases the GOCART aerosol module is held fixed. Results of the different simulations are intercompared and evaluated in the context of aerosol remote sensing observations from MODIS, MISR, AERONET, and CALIOP. Spatial resolution is considered by running the system at grid resolutions varying from about 2º (typical of climate simulations) to 0.5º (typical of global weather forecasting systems). Meteorology is considered by driving the model with either internally generated winds or else by replaying from the MERRA meteorological reanalysis. For all cases we consider the resulting diversity among the simulated aerosol distributions and properties, in comparison with observations, as well as the impact on computed aerosol radiative fluxes.

G.Curci

Aerosol Composition Retrieval from Satellite Observations using Neural Networks

Aerosol composition from satellite is usually presented in terms of groups of “aerosol types” or “aerosol models” (e.g. dust-like, continental, maritime, soot-containing, etc.) that may be identified by the specific algorithm. The selection of one such aerosol model is also often implied in the retrieval algorithm of related quantities such as the aerosol optical depth, and may induce significant uncertainty on the results. Here we explore the possibility of identifying a different set of aerosol classes, more closely comparable to in situ measurements and model simulations. The classes are inorganic ions (sum of sulfate, ammonium nitrate), organic matter, black/brown carbon, soil dust and sea salt. To this end, we produced a simulated set of paired aerosol scenes and reflectances at top-of -atmosphere, in order to train a neural network to recognize the aerosol classes from the reflectances. The aerosol fields are taken sampling randomly the 1-year simulation of a global chemistry-transport model (GEOS-Chem), thus representing many possible aerosol mixtures occurring over the globe. Only scenes over the oceans are selected in this first experiment to enhance contrast with the surface. The optical properties are calculated from simulated aerosol fields under different alternative assumptions on physical-chemical properties of the components (e.g. refractive indices, density, hygroscopic properties) and mixing state

(external or internal mixtures). The reflectances are then simulated using a radiative transfer model (libRadtran) at 1 nm spectral resolution in the range 350-1000 nm, assuming observation geometry typical of a polar orbiting satellite (such as MODIS, Hyperion, Sentinel-3, etc.). We discuss the potential for hyper- and multi-spectral satellite observations, to constraint the relative abundance of the selected aerosol classes. We also discuss potential limitations to the identification procedure dependent on the observation characteristics.

G.De Leeuw L. Sogacheva, P. Kolmonen, G. Saponaro, T.H. Virtanen, E. Rodriguez, K. Atlaskina and A.-M. Sundström

Retrieval of Aerosol and Cloud Properties from ATSR using ADV/ASV

The ATSR Dual View (ADV) and ATSR Single View (ASV) aerosol retrieval algorithms have been developed for use with the Along Track Scanning Radiometer ATSR-2 which flew on the ERS-2 satellite (1995-2003) and the Advanced ATSR (AATSR) which flew on the ENVISAT satellite (2002-2012) (both from the European Space Agency, ESA). The ATSR instruments provide two views: one near-nadir and the other at 55 degrees forward. Each view provides the radiances at the top of the atmosphere (TOA) in 7 wavebands from the visible (VIS) to the thermal infrared (TIR). This wide spectral range allows for both effective cloud screening and the retrieval of cloud properties. Combined with the dual view, the contributions from surface-induced and path radiances in cloud-free conditions can be effectively separated to determine the aerosol properties over land with high quality. Over ocean only one of the views is used (forward) and also here the quality of the data is competitive with that of other instruments. The advantage of the ATSR-2/AATSR combination is that it provides a time series of 17 years, longer than any other of the currently available quality products (MODIS, MISR, SeaWiFS). This time series will be further expanded with those from the Sea and Land Surface Temperature Radiometer (SLSTR) on the ESA/EU GMES Sentinel-3 mission which is planned to be launched in the autumn of 2015. The Dual View algorithm provides aerosol data on a global scale with a default resolution of 10x10km^2 (L2) and an aggregate product on 1^o x1^o (L3). Optional, a 1x1 km^2 retrieval products is available over smaller areas for specific studies. Since for the retrieval of AOD no prior knowledge is needed on surface properties, the surface reflectance can be independently retrieved using the AOD for atmospheric correction. In the presentation an overview will be presented of the aerosol and cloud remote sensing activities and applications at FMI and UHEL. The application of ADV/ASV to produce and AOD ECV for 17 years, with applications over different locations across the world, shows the different temporal variations of the AOD between 1995 and 2012. Spatial variations will be highlighted. The simultaneous retrieval of aerosol and cloud properties provides information on aerosol-cloud interaction.

M.Deushi K. Yoshida, H. Yoshimura and N. Oshima

Dependence of stratospheric mean age of air on model resolution and transport scheme in REF-C1 simulations

In this study, dependence of stratospheric mean age of air (AoA) on model vertical resolution and transport scheme is investigated, using the Meteorological Research Institute (MRI) climate model. Some sensitivity experiments, which were performed to improve a transport scheme in the model, shows relaxation of monotonicity constraints at departure points in the (semi-Lagrangian) tranport scheme considerably reduces model biases of AoA. This can be because numerical diffusion artificially arises in transport processes decreased significantly. A higher order interpolation, which is used to calculate tracer concentrations at the departure points, is also effective in decreasing the model biases. Next, sensitivity of simulated AoA to model vertical resolution is investigated using the above improved transport scheme. We performed REF-C1 runs.

S.Dhomse, G. Mann, K. Carslaw, J. Flemming, J.-J. Morcrette, R. Engelen, S. Remy, O. Boucher, W. Hewson and M. Woodhouse

Evaluation of global aerosol properties simulated by the high resolution coupled chemistry-aerosol-microphysics model C-IFS-GLOMAP

The EU Framework Programme GEMS and MACC consortium projects co-ordinated by the European Centre for Medium-range Weather Forecasts (ECMWF) have developed an operational global forecasting and reanalysis system (Composition-IFS) for atmospheric composition including greenhouse gases, reactive gases and aerosol. The current operational C-IFS system uses a mass-based aerosol model coupled to data assimilation of Aerosol Optical Depth measured by satellite (MODIS) to predict global aerosol properties. During MACC, the GLOMAP-mode aerosol microphysics scheme was added to the system, providing information on aerosol size and number for improved representation of aerosol-radiation and aerosol-cloud interactions, accounting also for simulated global variations in size distribution and internally-mixed particle composition. The IFS-GLOMAP system has recently been upgraded to couple with the sulphur cycle simulated in the online TM5 tropospheric chemistry module for global reactive gases. This C-IFS-GLOMAP system is also being upgraded to use a new “nitrate-extended” version of GLOMAP which realistically treats the size-resolved gas-particle partitioning of semi volatile gases ammonia and nitric acid. In this poster we described C-IFS-GLOMAP and present an evaluation of the global sulphate aerosol distribution simulated in this coupled aerosol-chemistry C-IFS-GLOMAP, comparing to surface observations in Europe, North America and the North Atlantic and contrasting to the fixed timescale sulphate production scheme developed in GEMS. We show that the coupling to the TM5 sulphur chemistry improves the seasonal cycle of sulphate aerosol, for example addressing a persistent wintertime sulphate high bias in northern Europe. The improved skill in simulated sulphate aerosol seasonal cycle is a pre-requisite to realistically characterise nitrate aerosol since biases in sulphate affect the amount of free ammonia available to form ammonium nitrate.

A.Di Noia

Application of neural networks to aerosol retrievals from PARASOL over ocean: First results

Thanks to its capability of measuring intensity and linear polarization parameters of the radiation at the top of the atmosphere at multiple wavelengths and viewing angles, the PARASOL instrument has provided us with an unprecedented amount of information about atmospheric aerosols. While a number of variational retrieval algorithms – based on on-line radiative transfer calculations – have been developed to retrieve the aerosol properties from PARASOL data, the application of such algorithms in an operational environment is challenging because of the vast amount of computer power required in each iteration. Another problem with spectro-polarimetric aerosol retrievals is the strong nonlinearity of the inverse problem, which makes its solution highly dependent on the initial guess. In order to address these issues, we are exploring the possibility of introducing neural network algorithms in our PARASOL retrieval chain. Our initial goal is to use neural networks to generate an accurate initial guess for the variational algorithm, in a way that is computationally more efficient than the current method, based on a look-up table. Our long term goal is to investigate whether neural networks can be accurate enough to replace the whole variational algorithm for PARASOL. In this poster we will show preliminary results of the application of neural networks to aerosol retrievals from simulated and real PARASOL measurements over ocean. The accuracy of retrievals performed on real data will be assessed through comparisons with co-located AERONET measurements.

O.Dubovik

Detailed properties of aerosol retrieved from satellites using GRASP algorithm

GRASP (Generalized Retrieval of Aerosol and Surface Properties) is new algorithm was developed recently by Dubovik et al. (2011, 2014) with objective of achieving complete and accurate characterization of aerosol and surface properties. It has following specific features: (i) GPASP searches in continuous space of solutions and doesn't utilize look-up-tables and all radiative transfer calculations are implemented directly during retrieval; (ii) it is based on highly elaborated statistically optimized fitting. For example, it uses multi-pixel retrieval when statistically optimized inversion is implemented simultaneously for a group of satellite pixels. These features allow using additional a priori information about known variability of aerosol of surface properties in time and/or space. As a result, GRASP doesn't use any specific information about aerosol or surface type in the each observed pixel, the retrieval starts from unique initial guess and the results are essentially driven by observations. However GRASP takes longer computational time compare to most conventional algorithms that is the main practical difficulty of employing GRASP for massive data processing. Nonetheless, in last two years, GRASP has been significantly optimized and adapted to operational needs. As a result of this optimization, GRASP has been accelerated to the level acceptable for processing large volumes of satellite observations. Recently GRASP has been applied to multi-years archives of PARASO/POLDER and ENVISAT/MERIS. Based, on the preliminary analysis GRASP results are very promising for comprehensive characterization of aerosol

even for observations over bright surfaces and for monitoring very high aerosol loading events (with AOD 2 and over). In addition, it was made the attempts to estimate such aerosol characteristics as aerosol height, air mass, radiative forcing, aerosol type, etc. The results and illustrations will be presented.

R.Ferrare

Comparisons of Airborne HSRL and Modeled Aerosol Profiles

Aerosol profiles acquired by NASA Langley Research Center (LaRC) airborne High Spectral Resolution Lidars (HSRLs) are compared with corresponding profiles produced by AEROCOM models as well as by ECMWF/MACC-III and NAAPS operational forecast models. Comparisons of aerosol extinction profiles acquired by the CALIOP lidar on the NASA CALIPSO satellite and produced by the AEROCOM models have shown differences near the surface as well as in the mid-upper troposphere. Consequently, to further evaluate the AEROCOM profiles, we evaluate AEROCOM Phase II aerosol extinction profiles with coincident aerosol extinction profiles measured by the airborne HSRL-1 instrument during twelve field missions conducted over North America and the Caribbean Sea between 2006 and 2008. HSRL-1 measured profiles of aerosol backscatter and depolarization (532, 1064 nm) and aerosol extinction and optical thickness (AOT) (532 nm). We also compare aerosol profiles produced by the ECMWF/MACC-III and the NAAPS global aerosol transport models with those measured by the airborne LaRC DIAL/HSRL instrument during August and September 2013 when this airborne lidar 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 model simulations of forest fire smoke over the western U.S. The DIAL/HSRL measurements are also used to evaluate the impacts on the MACC-III aerosol extinction profiles produced by assimilating MODIS and CALIOP data and by changing the horizontal and vertical model resolutions.

M.Fiebig

Confronting AeroCom models with particle size distribution data from surface in situ stations, episode 2

The size distribution is the most important property for describing any interaction of an aerosol particle population with its surroundings. In first order, it determines both, the aerosol optical properties quantifying the direct aerosol climate effect, and the fraction of aerosol particles acting as cloud condensation nuclei quantifying the indirect aerosol climate effect. Aerosol schemes of modern climate models resolve the aerosol particle size distribution (APSD) explicitly. In improving the skill of climate

models, it is therefore highly useful to confront these models with precision APSD data observed at surface stations. Corresponding previous work focused on comparing size integrated, seasonal particle concentrations at selected sites with ensemble model averages to assess overall model skill. Building on this work, this project intends to refine the approach by comparing median particle size and integral concentration of fitted modal size distributions. It will also look at skill differences between models in order to find reasons for matches and discrepancies. The presentation will outline the project, and will elaborate on input requested from modelling groups to participate in the exercise.

S.Fielder

An observation-based parameterization of aerosol optical properties

State-of-the-art climate models show large uncertainties in the aerosol forcing of the Earth system. Reasons for model diversity include differences in the aerosol parameterization, the background atmospheric state, and the response mechanisms to aerosol perturbations. A key aspect of the latter is believed to be the interaction of atmospheric circulation, clouds and precipitation (Bony et al., 2015). The intertropical convergence zone (ITCZ) is important for the location of tropical rainfall maxima and migrates towards the hemisphere of stronger warming. Hemispheric asymmetries in warming can be modified by anthropogenic aerosol. However, the response of the ITCZ to warming depends on the representation of clouds (Voigt and Shaw, 2015). Assessing the relative importance of model differences in circulation and clouds compared to aerosol effects would help to better understand model uncertainty in aerosol forcing. The new observation-based parameterization MACv2-SP for aerosol optical properties is being developed at the Max Planck Institute for Meteorology (MPI-M) for use by CMIP6 models participating in the “Radiative Forcing Model Inter-comparison Project” (RFMIP). MACv2-SP represents monthly varying plumes of anthropogenic fine-mode aerosol at and downwind of major source regions. The aerosol parameterization is based on the updated climatology MACv2 (Kinne et al., 2013), which uses remote sensing and global aerosol-climate model results of AEROCOM to determine the four dimensional distribution of AOD, single scattering albedo and asymmetry parameter. In MACv2-SP, this climatology is approximated by functional relationships to derive a computationally efficient, scientifically flexible, and easily applicable parameterization. In preparation of using MACv2-SP in the MPI-M’s Earth System Model (ESM), the performance of MACv2-SP in the MPI-ESM’s radiation scheme PSrad (Pincus and Stevens, 2013) is systematically tested. Here, the new offline version PSrad-O is used. PSrad-O is validated with idealized radiation transfer calculations following the protocol of Randles et al. (2014), which shows a good agreement with their results. Using MACv2-SP in ESMs will allow to inter-compare response mechanisms of the ITCZ to anthropogenic aerosol perturbations and to test the hypothesis (Stevens, 2015) that the historical evolution of the response to aerosol forcing can constrain the magnitude of the present day forcing.

P.Forster

RFMIP and its connection to AerCHemMIP

Outline of the CMIP6 endorsed project RFMIP designed to assess radiative forcing in CMIP6 models in close conjunction with AerCHemMIP.

M.Garay, M.A. Bull, D.J. Diner and E.G. Hansen

Resolution and Content Improvements to the MISR Operational Aerosol Product

Since early 2000, the Multi-angle Imaging SpectroRadiometer (MISR) instrument on NASA's Terra satellite has been providing operational Level 2 (swath-based) aerosol optical depth (AOD) and particle property retrievals at 17.6 km spatial resolution. The performance of this product has been validated against ground-based Aerosol Robotic Network (AERONET) observations, model comparisons, and climatological assessments. MISR aerosol data have also played a major role in studies of the impacts of aerosols on climate and air quality. A major development effort has led to the release of an update to the operational (Version 22) MISR Level 2 aerosol products, which has been in production since December 2007. The new release is designated Version 23. Motivated by the needs of the air quality community, the resolution of the aerosol product has been increased to 4.4 km, allowing more detailed characterization of aerosol spatial variability, especially near local sources and in urban areas. The product content has been simplified and updated to include more robust measures of retrieval uncertainty and other fields to benefit users. We will describe the major upgrades incorporated in Version 23 and present validation of the aerosol product against both the standard AERONET historical database, as well as high spatial density AERONET-DRAGON deployments. Comparisons will also be shown relative to the Version 22 aerosol product. Applications enabled by these product updates will be discussed, particularly for studies in urban areas.

A.Gettelman. A. Schmidt, J.E.Kristjansson and J.Stith

Tropospheric Volcanic Aerosols and Climate: Past and Present Impacts for Testing Aerosol-Cloud Interactions

Volcanic emissions of sulfur in the stratosphere have long term effects on climate by directly scattering solar radiation. But recent work has shown that emissions of volcanic sulfur into the troposphere may also have climatic impacts by indirect effects of aerosol-cloud interactions. Here we highlight recent work on possible effects of tropospheric sulfur from recent and historical tropospheric eruptions. We also discuss the opportunities to use these emissions as a natural laboratory for testing aerosol-cloud interactions.

S.Ghan

Constraining Cloud-Aerosol Interactions in Climate Models

A large number of processes are involved in the chain from emissions of aerosol precursor gases and primary particles to impacts on cloud radiative forcing. Those processes are manifest in a number of relationships that can be expressed as sensitivity factors dlnX/dlnY driving aerosol effects on cloud radiative forcing. These factors include the sensitivity of cloud condensation nuclei (CCN) concentration to emissions, droplet number to CCN concentration, cloud optical depth to droplet number, and cloud radiative forcing to cloud optical depth. The relationship between cloud optical depth and droplet number can be further decomposed into the sum of two terms involving the sensitivity of droplet effective radius and cloud liquid water path to droplet number. These relationships can be constrained using observations of recent spatial and temporal variability of CCN concentration, droplet number concentration, droplet effective radius, cloud liquid water path, cloud optical depth, and cloud radiative forcing. However, analysis of AeroCom model simulations suggests the relevance of such constraints to anthropogenic aerosol impacts on cloud radiative forcing is doubtful for some terms. Proxies connecting recent spatial/temporal variability to anthropogenic change, or sustained measurements in regions where emissions have changed, are needed to constrain estimates of anthropogenic aerosol impacts on cloud radiative forcing.

P.Ginoux

Anthropogenic dust experiment

It has been estimated that 10 to 25% of dust load is from anthropogenic origin. The particularity of dust from agriculture is its rich iron content in the fine mode and its mixture with nitrate in the coarse mode. Most models include only natural aerosols. We propose an experiment where anthropogenic dust emission is also included, and optical properties of fine and coarse modes dust are adapted to iron rich agricultural soil with NH3 fertilization.

Y.Govearts

MFG/MVIRI potential for aerosol retrieval

The Meteosat satellites play an important role for the generation of consistent long time series of aerosol properties. This importance relies on (i) the long duration of past (Meteosat First Generation, MFG) starting in 1982, present (Meteosat Second Generation, MSG) and future (Meteosat Third Generation, MTG) missions and (ii) their frequent cycle of acquisition that can be used to document the anisotropy of the surface and therefore the lower boundary condition for aerosol retrieval over land

surfaces. Daily accumulation of the frequent Meteosat observations is used to discriminate the radiative effects that result from the surface anisotropy, from those caused by the aerosol scattering. The inverted forward model explicitly accounts for the surface anisotropy and the multiple scattering for the coupled surface-atmosphere system. Pinty et al. (2000) pioneered with the development of an original method to characterise simultaneously surface anisotropy and atmospheric scattering properties for the processing of MFG. Although these observations are limited to one single large VIS band poorly characterised, the main advantage of MFG relies in the duration of the archive (1982 – 2006), knowing that prior to 2000 space observations were very scarce. Despite these radiometric limitations, it is possible to detect major aerosol events like dust storms, fire plumes or pollution events, even over land surfaces. Additionally, recent efforts have been undertaken in the framework of the H2020 FIDUCEO project to improve the characterization of the VIS band spectral response.

E. Gryspeerdt

The aerosol optical depth - cloud fraction relationship in observations and global models

Aerosols are able to influence cloud properties both through their interactions with radiation and through their ability to act as cloud condensation nuclei (CCN). However, the magnitude of the aerosol influence on cloud properties is highly uncertain. A strong positive correlation between aerosol optical depth (AOD) and cloud fraction (CF) has been observed in satellite data, but it is unclear to what extent this relationship is due to an aerosol influence on cloud properties. The confounding influence of local meteorology obscures the magnitude of any aerosol influence on CF. For example, both AOD and CF increase in humid environments, generating a correlation between them. Previous studies have used reanalysis data to account for confounding meteorological variables. This requires knowledge of the relevant meteorological variables and is limited by the accuracy of the reanalysis data. Recent work has shown that by using the cloud droplet number concentration (CDNC) to mediate the AOD-CF relationship, the impact of relative humidity can be significantly reduced. This method removes the limitations imposed by the finite accuracy of reanalysis data. In this work we examine how the impact of CDNC mediation on the AOD-CF relationship is represented in global atmospheric models. By comparing pre-industrial and present day runs, the ability of the CDNC mediated AOD-CF relationship to determine the strength of the aerosol influence on CF is examined, helping to determine whether the satellite-derived relationship provides a constraint on the aerosol indirect forcing due to changes in CF.

M.Grzegorski

Retrieval of aerosol optical properties over land using PMAp

The retrieval of aerosol optical properties is an important task for industry and climate forecasting. An ideal instrument should include observations with moderate spectral and high spatial resolutions for a

wide range of wavelengths (from the UV to the TIR), measurements of the polarization state at different wavelengths and measurements of the same scene for different observation geometries. As such an ideal instrument is currently unavailable the usage of different instruments on one satellite platform is an alternative choice. Since February 2014, the Polar Multi sensor Aerosol product (PMAp) is delivered as operational GOME product to our customers. The algorithms retrieve aerosol optical properties over ocean (AOD, volcanic ash, aerosol type) using a multi-sensor approach (GOME, AVHRR, IASI). In Q1/1016 a new release (PMAp2) will be implemented for data dissemination to our users. PMAp2 provides an extended set of aerosol and cloud properties which include AOD over land and an improved volcanic ash retrieval combining AVHRR and IASI. This presentation gives an overview on the new operational product PMAp2 with a focus on AOD retrieval over land. In addition, the results of our current validation studies (e.g. comparisons to other satellite platforms and AERONET stations) are shown.

H.C.Hansen J. Acosta-Navarro, V. Varma, I. Riipinen, , Ø. Seland , A. Kirkevåg, H. Struthers, T. Iversen

How does European aerosol emissions affect the Arctic climate?

The Arctic is warming considerably faster than the rest of the globe1 having long-lasting consequences for the ecosystems and human exploration of the region. The exact reasons behind this Arctic amplification are still inconclusive. Due to air quality measures, anthropogenic emissions of particulate matter and its precursors have drastically decreased in parts of the Northern hemisphere during the past three decades5. We show that the sulfate aerosol reductions in Europe have modified the atmospheric heat transport towards the Pole and that the decrease in aerosol burden over Europe can explain a significant fraction of the recent Arctic warming. The primary reason for this is that the aerosol induced positive radiative flux perturbation at the top of the atmosphere over mid-latitudes has been compensated by an increased poleward dry-static heat transport. This response is contrary to the decrease in poleward dry-static heat transport associated with increased atmospheric concentrations of CO2. The results reveal a unique inherent link between air quality regulations in the Northern hemisphere, general circulation and Arctic climate.

O.Hasekamp

Polarimetric Remote Sensing of Atmospheric Aerosols

To reduce the large uncertainty on the aerosol effects on cloud formation and climate, accurate satellite measurements of aerosol optical properties (optical thickness, single scattering albedo, phase function) and microphysical properties (size distribution, refractive index, shape) are essential. Satellite instruments that perform multi-angle photo-polarimetric measurements have the capability to provide these aerosol properties with sufficient accuracy. The only satellite instrument that provided a multi-year data set of multi-angle photo-polarimetric measurements is the POLDER-3 instrument onboard the PARASOL microsatellite that operated between 2005-2013. PARASOL provides measurements of a ground scene under (up to) 16 viewing geometries in 9 spectral bands (3 for polarization). In order to

make full use of the capability of PARASOL measurements of intensity and polarization properties of reflected light at multiple viewing angles and multiple wavelengths, we developed a retrieval algorithm that considers a continuous parameter space for aerosol microphysical properties (size distribution and refractive index) and properly accounts for land or ocean reflection by retrieving land and ocean parameters simultaneously with aerosol properties. Here, we present the key aspects of our PARASOL retrievals (inverse method, forward model, information content, cloud screening, computational aspects) as well as a validation of retrieved aerosol properties with ground-based measurements of the AERONET network. Also, we discuss required improvements for the next generation of polarimetric instruments dedicated to aerosol remote sensing and introduce a new spectropolarimetric instrument named SPEX. We will demonstrate the capabilities of SPEX based on ground based field measurements and characterization measurements in the laboratory.

M.Hegglin

New CCMI ozone database for use in CMIP6

In this contribution we will present plans for the generation of a new historical and future ozone data-base to be used in the Coupled Model Intercomparison Project phase 6 (CMIP6) model simulations that do not include interactive atmospheric chemistry. The inclusion of realistic distributions of short-lived climate forcers such as ozone is important for climate change attribution and projection, since these can lead to inhomogeneous forcings of climate, as has been shown for the effect of the Antarctic ozone hole on surface climate during austral summer. The ozone forcing data-base generated within the proposed project will be an update of the ozone forcing provided by the SPARC Chemistry-Climate Model Validation (CCMVal) activity to CMIP5 and based on new simulations that will become available from the CCMI chemistry-climate models that resolve both stratospheric and tropospheric chemistry.

C.Ichoku

Level-2 AOD median from multiple satellite sensor retrievals

A variety of sophisticated algorithms developed and refined over the last couple of decades are being used to retrieve aerosol products from various spaceborne sensors, including MODIS on the Terra and Aqua satellites, MISR on Terra, OMI on Aura, POLDER on PARASOL, CALIOP on CALIPSO, and SeaWiFS on SeaStar. However, significant differences still exist when similar aerosol products are collocated and compared among themselves or against corresponding parameters from the worldwide ground-based Aerosol Robotic Network (AERONET) of sunphotometers. These satellite aerosol retrievals have been carefully and uniformly analyzed and inter-compared relative to AERONET, in order to understand their uncertainties and limitations. The next step is to develop a unified consensus satellite aerosol product through synergistic approaches that harvest the best qualities of the different independent products in time and space to constitute an optimal unified product. In this presentation, we will show the prototype of a multi-satellite aerosol product unification concept based on level-2 (L2) aerosol optical

depth (AOD) median estimates and their comparisons with collocated ground-based AOD measurements from AERONET.

B.Johnson

Model and satellite reveal large aerosol-cloud interactions from Icelandic eruption Holuhraun

During the period September 2014 - February 2015, a significant fissure eruption occurred in the Holuhraun area of Iceland. Unlike the well documented eruption of Eyjafjallajökull in 2010, this eruption received relatively little public attention as the low altitude emissions had little accompanying ash and had no impact on trans-Atlantic air-traffic. However, the emission rates of sulphur dioxide during the first two months of eruption were at least four times those from the entire 28 European member states and by the end of the eruption the total sulphur dioxide emitted exceeded the total annual emission targets of all of Europe. This eruption provides an ideal test bed for validating models and inter-comparing observations of aerosol-cloud-interactions. We provide global modelling and satellite estimates of the impact of the sulphur dioxide emissions on cloud microphysics across the North Atlantic region. The impact on cloud droplet size is clearly identified in MODIS retrievals with pristine clouds of lesser reflectivity replaced by polluted clouds of higher reflectivity. Simulations with HadGEM3 including a detailed aerosol-microphysical scheme show excellent agreement with observations of cloud effective radius and cloud droplet number concentration. We also use the model to assess impacts on other variables such as aerosol optical depth, cloud liquid water path, cloud optical depth and radiation forcing, and the extent to which these impacts are detectable. We conclude that, just as the explosive eruption of Pinatubo into the stratosphere provided the basis for many model and satellite analysis and inter-comparisons, the Holuhraun eruption provides a similar counterpart for focussing analyses of tropospheric cloud-aerosol interactions.

O.Jorba

Aerosol Modelling with the global online NMMB/BSC Chemical Transport Model

The Barcelona Supercomputing Center (BSC) does research on atmospheric chemistry, mineral dust transport and air quality. The center is working on the development of a chemical weather forecasting system based on the NCEP/NMMB multiscale meteorological model (Janjic and Gall, 2012), namely NMMB/BSC Chemical Transport Model (NMMB/BSC-CTM; Pérez et al., 2011; Jorba et al., 2012; Spada et al., 2013). A gas-phase chemistry module and a multi-component aerosol scheme have been coupled online with the NMMB. In this contribution, we describe and evaluate the fully online-coupled aerosol module simulating the lifecycle of the most relevant global aerosols (i.e. mineral dust, sea-salt, black carbon, primary and secondary organic aerosols, and sulfate). Following the capabilities of its

meteorological core, the model has been designed to simulate both global and regional scales with unvaried parameterizations: this allows detailed investigation on the aerosol processes bridging the gap between global and regional models. We evaluate our simulations using a variety of observations and measurement techniques. Surface concentration of black carbon, organic carbon, and sulfate are compared with observations from the IMPROVE, EMEP, and EANET continuous measurement. Global aerosol transport is evaluated also by comparing aerosol concentrations with worldwide observations from the University of Miami Network. The simulated aerosol optical depth is evaluated against global AERONET sun-photometer measurements and MODIS satellite retrievals. Additionally, we discuss our results in comparison to other global models within AEROCOM and ACCMIP.

R.Kahn

Progress Toward A Global Aerosol-Type Climatology

Although a global climatology of aerosol optical depth (AOD) for testing and constraining aerosol models has been derived from satellite and suborbital measurements, a corresponding climatology of aerosol type has been more elusive. Compared to AOD, aerosol type retrievals are much more sensitive to observing conditions; in addition there is much less aerosol-type validation data. Improvements in remote-sensing retrieval algorithms themselves represent part of the needed advance. This includes refining instrument calibration beyond the standard pre-launch values, especially band-to-band relative calibration, and improving the microphysical properties of aerosol components and mixtures assumed in algorithm climatologies. There is also an immense gap in the available measurements of mass extinction efficiencies (MEEs) used to translate between remote-sensing optical constraints and the aerosol mass book-kept in climate models. Obtaining the needed microphysical detail requires systematic in situ measurement of all the relevant quantities for the major aerosol types globally. The SAM-CAAM (Systematic Aircraft Measurements to Characterize Aerosol Air Masses) concept, that aims to acquire such data, is in development. Work within the AeroCom and AeroSat communities to apply satellite data to constraining aerosol source strength and injection height is underway, addressing another key area where progress is being made. As this work advances, we also need to consider ways of using model simulations to help fill in gaps in the global measurements of aerosol type that occur, e.g., when the AOD is too low for aerosol-type retrievals. Finally, there is a need for next-generation satellite instruments that at least maintain, if not improve upon, current aerosol-type mapping capabilities. Several aircraft prototypes have been developed, but support and involvement of the AeroCom community could make a large difference in when and how future measurement programs unfold.

O.Kalashnikova F. Xu, C. Ge, J. Wang, M.J. Garay, D.J. Diner, Huikyo Lee, K. Suzuki, A. Braverman and R.A. Kahn

Constraining PM speciation by combining multiangular and polarimetric remote sensing with in-situ observations and chemical

transport modeling

It is well established that much of the world's population faces serious health risks as a consequence of breathing air contaminated by airborne particular matter (PM). However, due to limitations of current data, relationships between *specific* particle types and health outcomes are much less certain. Surface stations are too sparsely distributed to provide the level of spatial detail needed to link different aerosol species to given health effects, and expansion to denser coverage is impractical and cost prohibitive. Remote sensing has considerable potential for quantifying the spatial and temporal distribution of specific PM types; however, the linkages between aerosol optical properties retrieved by remote sensing techniques and aerosol chemical composition measured *in situ* must first be well established. A significant aerosol remote sensing challenge in retrieving spatial information on *specific* aerosol types, especially near the surface, is due to lack of information on the vertical distribution of aerosols in the atmospheric column and limited sensitivity to aerosol types over land. To address this challenge we describe a new approach that uses the additional information contained in multiangle, spectro-polarimetric remote sensing imagery constrained with a first-guess from a chemical transport model (CTM) to retrieve spatial distributions of near-surface and atmospheric particulate matter (PM) – including different types of carbon-containing particles that are well known to have adverse health effects. As a first step, we demonstrate this approach by bringing together JPL's Airborne Multiangle Spectro-Polarimetric Imager (AirMSPI) data, high-resolution Weather Research & Forecasting (WRF)-Chem aerosol modeling, and information from speciated Environmental Protection Agency (EPA) PM monitors located in California's San Joaquin Valley (SJV) for two cases of elevated aerosol loadings. Next, we discuss an upcoming field campaign designed to establish linkages between multiangular spectro-polarimetric radiances observed remotely and aerosol size and chemical composition. For this campaign we will employ JPL's AirMSPI and the Caltech Campus suite of science instruments on the CIRPAS Twin Otter in conjunction the information from a CTM and ground based monitors.

Climatology of component aerosol optical depth from MISR compared with atmospheric chemistry models

The Multi-angle Imaging SpectroRadiometer (MISR) Level 3 Joint Aerosol (JOINT_ AS) product provides a global, descriptive summary of MISR Level 2 aerosol optical depth (AOD) and aerosol type information for each month between March 2000 and the present. Using the operational version (V22) of JOINT_AS this study, for the first time, analyzed the distributions of optical depth for three types of aerosols: non-absorbing, absorbing, and dust, near and downwind of their major source regions in comparison with a high-resolution atmospheric chemical transport model. Various statistical moments of the AOD by component, including the mean, standard deviation, and skewness, derived from JOINT_AS were compared with results from the Spectral Radiation-Transport Model for Aerosol Species (SPRINTARS). We found that overall the AOD distributions of combined MISR aerosol types are comparable to those from SPRINTARS. Marginal distributions of AOD for each aerosol type in both MISR and SPRINTARS show considerable high positive skewness their distributions, which indicates the importance of considering extreme AOD events when comparison observations and models. In addition, the average and seasonal cycle in MISR's AOD by component were compared with those of carbonaceous, sulfate aerosols, and dust particles from the chemistry climate models (CCMs) participating in the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP). In the Sahara Desert, as an example, we found that due to the unspecified dust emissions in the ACCMIP simulations, MISR and the CCMs

show noticeable difference in the seasonal cycle of dust AOD, but good agreement in total AOD. In addition, non-absorbing AOD in East Asia and absorbing AOD in West Africa vary significantly between MISR and the CCMs.

T.Keslake M. Chipperfield, G. Mann, S. Dhomse. J. Flemming, S. Remy and W. Morgan

Biomass burning influences on atmospheric composition: a case study to assess the impact of aerosol and gas phase data assimilation

The C-IFS (Composition Integrated Forecast System) developed under MACC and continued under CAMS, provides global operational forecasts and re-analyses of atmospheric composition at high spatial resolution (T255, ~80km). In this study we present results from C-IFS experiments with and without composition data assimilation, in particular exploring how the approach improves the representation of biomass burning influences in the Amazon, comparing to independent observations from the SAMBBA field campaign in 2012. As emissions significantly influence gas-phase chemistry and aerosol concentrations, tropical biomass burning (BB) is influencing regional atmospheric composition and climate. Smoke particles can influence incoming and diffuse radiation, while high enough ozone concentrations are known to limit plant productivity. With T255 horizontal resolution the C-IFS model system provides insight into the evolution of mixed BC/POM smoke particles, ozone and its precursors at high global model resolution. There are 2 aerosol schemes currently used in C-IFS, as simpler mass-based scheme (GEMS-AER) and an aerosol microphysics scheme (GLOMAP-mode), the former currently used operationally with AOD data assimilation. We carry out parallel free-running C-IFS simulations with GEMS-AER and GLOMAP-mode and explore how simulated biomass burning aerosol properties differ between the two schemes. Data assimilation can also help quantify the budget of primary and secondary emitted species and test the current descriptions of their chemical and physical feedbacks present in the models. By comparing a C-IFS reanalysis, hind-cast runs initialised from reanalysis and free-running model runs, we gain further insight into the bias present in the model system.

S.Kinne

Aerosol radiative effects and climate impact (radiative forcing)

Based on the MACv2 aerosol climatology for aerosol optical properties estimates for the aerosol direct and the aerosol (first) indirect effects are offered. The first indirect effect is compared to central estimates from global modeling (AeroCom 2 output) and satellite remote sensing (MODIS and AATSR).

Z.Kipling

Quantifying global aerosol effects on convection using the Convective Cloud Field Model (CCFM)

Considerable advances have been made in the last decade or so in the representation of aerosol indirect effects on resolved-scale cloud and precipitation in global climate models. However, the representation of effects on the convective scale is severely limited by the nature of the bulk mass-flux parameterisations used in most global models. In this study, we investigate these effects using the Convective Cloud Field Model (CCFM) within the ECHAM6-HAM2 global aerosol-climate model. CCFM simulates a spectrum of cloud types interacting through their shared environment, each modelled by an entraining parcel model with explicit updraught velocity and embedded parameterisations of aerosol activation and cloud microphysics. This allows us to analyse the distributions of updraught velocity and cloud droplet number concentration (CDNC) in unresolved convective cloud, as well as the cloud field structure in terms of cloud number, area and depth. We then consider the effect of an aerosol perturbation on this system, investigating impacts at the cloud, cloud field and global scale, leading to an estimate of the convective contribution to global ERFaci.

A.Kirkevag K. Alterskjær, A. Grini, T. Iversen, D. Olivie, Ø. Seland and M. Schulz

Preliminary estimates of Aerosol Effective Radiative Forcing in CAM5-Oslo/NorESM2

We present preliminary effective radiative forcing (ERF) results from simulations with CAM5-Oslo (the atmosphere module in NorESM2), using nudged meteorology from CAM5 and IPCC AR5 emissions of aerosols and precursors for present day (2000) and pre-industrial (1850) conditions. The model is an early version of the next generation atmospheric module of the Norwegian Earth System Model, NorESM1 (Bentsen et al., 2013; Iversen et al., 2013; Kirkevåg et al, 2013). It is basically an extended version of CAM5 (Liu et al., 2012) where schemes for aerosol chemistry, physics and interaction with clouds originally developed for NorESM1 exist as options alongside with the modal aerosol modules of CAM5. Important updates in aerosol chemistry and physics since NorESM1: new sea-salt aerosol treatment (Salter et al., 2015), explicit nucleation (based on Makkonen et al., 2014), and SOA. Work with the latter two is still in progress, but is expected to be on place in the model version for this presentation. Development of nitrate aerosol as part of the aerosol scheme is still in its early phase. Following Ghan (2013), ERF by anthropogenic 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.

L.Klüser

IASI Dust algorithm inter-comparison within ESA's Climate Change Initiative

The aerosol_cci project aims at a better characterization of the global aerosol load from satellite. One key element is the understanding of contributions from different kinds of aerosol to the overall budget. Desert dust is the largest contributor to global aerosol mass and moreover is assumed to have a high sensitivity to climate change. Within aerosol_cci four European satellite retrieval groups contribute with dedicated dust observations from the Infrared Atmospheric Sounding Interferometer (IASI). The four approaches use different assumptions and mathematics. Consequently altogether they offer a wide range of information about the airborne dust burden. A major task within the project is the first inter-comparison of IASI dust retrieval results on the basis of a large set of observations. Therefore one year of IASI observations (2013) over the major dust belt of the Northern hemisphere, including the Northern Atlantic Ocean, the Sahara desert, the Arabian Peninsula as well as the Central Asian desert regions, is consistently processed with all four algorithms and similar retrieval output (AOD at different wavelengths, uncertainty, retrieval quality, cloud flags) is generated in order to facilitate the comparison of results. First results show good agreement in the location of the dust plumes whereas the magnitude of the average dust AOD and the detection of singular dust events also include significant differences. Validation with external dust observations shows further sensitivities of the different algorithms. Comparison with MISR nonspherical AOD shows wide similarities in positions and magnitudes of dust plumes and dust sources. The MISR dataset can be used to understand under which conditions the different algorithms perform best and also to showcase improvements within aerosol_cci. Similar comparison is planned with POLDER dust AOD observations as soon as an overlapping period of one year is processed.

K.Knobelspiesse

Progress of the NASA ACE Mission Polarimeter Working Group instrument inter-comparison

The NASA Aerosol-Cloud-Ecosystem (ACE) mission is a National Research Council Decadal Survey recommended mission that will contain an imaging polarimeter for remote sensing of aerosols and clouds. A variety of airborne polarimeter prototypes exist, so the ACE Polarimeter Working Group (ACEPWG) was formed to share information between groups and collectively work for improved measurement techniques, uncertainty characterization, and algorithm development. The initial focus has been on observations made during the Polarimeter Definition Experiment (PODEX), conducted in early 2013 in Southern California. Three ACE mission supported polarimeters were deployed on the high altitude ER-2 aircraft as it flew over a variety of targets. Two of those instruments to date have successfully produced Level 1 (geolocated radiance and polarization) data. Initial matched scene inter-comparisons found little radiometric, but significant polarimetric, bias. After improvement to geolocation in one instrument, and calibration in the other, polarimetric comparisons have improved significantly. We will describe these results, remaining unresolved issues, and future plans.

H.Kokkola

Contribution of water to modeled aerosol direct effect

Modelled direct radiative forcing of aerosol in global aerosol models varies significantly making it currently one of the most uncertain factor in climate change. This variance in modeled aerosol direct radiative forcing is regionally even much larger indicating significantly different spatial difference in modeled aerosol load. This can be seen in global maps of aerosol optical depth (AOD) from AeroCom models. A significant fraction of aerosol optical depth comes from aerosol water which also varies significantly between different models. In this study, we investigate the reasons for these differences in the models. We investigate how differences in modeled aerosol composition, relative humidity, and size distribution contribute to differences in AOD and optical depth of aerosol water. We compared Aerocom II model data for aerosol optical depth against those observed by Moderate-Resolution Imaging Spectroradiometer (MODIS) instrument on board of Terra and Aqua satellites. Modeled relative humidities were compared against observations from the Atmospheric Infrared Sounder (AIRS) flying on board NASA's Aqua satellite and the National Centers of Environmental Prediction (NCEP) reanalysis data. According to our study, deviation of modeled relative humidity from observed relative humidity can have significant implications on modeled radiative effect. This effect is most prominent over the oceans where relative humidity is high and small variances in relative humidity cause large variance in aerosol wet size and thus their potential to affect solar radiation.

H.Korhonen

Model intercomparison of Remote Climate Impacts of anthropogenic Aerosols

Regional changes in climate will have profound impacts on people's lives; yet, the drivers of these changes remain poorly understood. An important complicating factor are atmospheric aerosol particles, which have a highly non-uniform geospatial distribution and can impact regional climate both locally (via changes in local radiation balance) and remotely (via changes in large-scale circulation). The RECIA project undertakes a unified climate model intercomparison experiment that systematically investigates these local and remote regional climate impacts using standardized particle aerosol fields. The models currently involved in the project are MPI-ESM, EC-Earth and NorESM, but contributions from other modelling groups are warmly welcome.

C.Lacagnina

Aerosol Single Scattering Albedo over the global oceans: comparing PARASOL retrievals with AeroCom models estimates

The aerosol Single Scattering Albedo (SSA) over the global ocean is evaluated based on polarimetric measurements by the PARASOL (Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar) satellite. For the first time, global ocean SSA and Absorption Aerosol Optical Depth (AAOD) from this instrument are shown and evaluated against other observations (the AErosol RObotic NETwork, AERONET, and the Ozone Monitoring Instrument, OMI). The observational data sets compare reasonably well, with the majority of the co-located points within 0.05 of the AERONET measurements. PARASOL shows that SSA is characterized by high spatial and seasonal variability, also over the open ocean far from the inland emission regions. The near global coverage in the visible spectral range provided by the PARASOL retrievals represents a unique opportunity to evaluate aerosol optical properties simulated by global aerosol models, as performed in the AeroCom framework. The SSA (AAOD) estimated by the AeroCom models is generally higher (smaller) than the SSA (AAOD) retrieved from PARASOL. On the other hand, the mean simulated AOD is consistent or slightly underestimated compared with observations. An overestimate of the aerosol scattering, compared to absorption, by the models would suggest that these simulate an overly strong aerosol radiative cooling at top-of-atmosphere, over most of the ocean surfaces. This implies that aerosols have a potentially stronger direct and semi-direct impact within the atmosphere than currently simulated.

L.Lee

Proposal for participation in a global aerosol multi-model perturbed parameter ensemble (MMPPE) within the international AeroCom project

We seek participants for a global aerosol multi-model perturbed parameter ensemble (MMPPE) within the AeroCom community. In this presentation the project is described including the motivation, objectives and the practicalities of participating in such an experiment. Huge investment in atmospheric measurements and computer modelling has improved our understanding of aerosol-climate processes, but our ability to constrain model uncertainty has remained almost unchanged for more than a decade. Large model uncertainty limits our ability to make precise predictions of future climate change. The vast majority of our understanding of model spread derives from multi-model ensembles (MMEs). Another (complementary) approach to understanding the causes of model uncertainty is to investigate the effects of perturbations to processes in a single model (so-called perturbed parameter or perturbed physics ensembles, PPEs), which is sometimes followed by sensitivity analysis. An example of this approach in global aerosol modelling is Lee et al. (2013) for global CCN and Carslaw et al. (2013) for indirect forcing. Whilst the sensitivity analysis in any one model produces valuable information for model development and evaluation to the modelling group involved, coordinated sensitivity analysis across multiple models has the potential to provide even more valuable information on the sources of multi-model diversity and the reasons for divergence of observationally constrained models. There is currently no framework to allow the uncertainty quantified from MMEs and PPEs to be combined, but such an advance is needed. The results, in the form of diagnosed uncertainties and their sources, will provide unprecedented information for future aerosol model development, and will be a major new

direction for AeroCom. This approach will generate more robust estimates of forcing uncertainty to feed into the next IPCC.

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. 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. One component of SSiRC involves an intercomparison of a new generation of Earth System Models that simulate the stratospheric aerosol layer interactively. Following the kick-off meeting for SSiRC in October 2013, one component of the SSiRC activity will be for each model to run "perturbed physics ensembles" (PPEs) of the Pinatubo eruption across several uncertain parameters. The Gaussian emulation approach will be carried out on each model to characterise and intercompare the magnitude and uncertainty of simulated climate effects.
In this poster presentation we will present the overall plan for this 'POEMS' analysis which will include an expert elicitation exercise to determine which uncertain parameters are to be varied and their uncertainty ranges.

R.Levy

Aerosol retrieval for MODIS, VIIRS and beyond

This presentation (or multiple presentations) will be about the dark-target (DT) aerosol retrieval, its application to MODIS and VIIRS, and its application to any other satellite or airborne sensor we feel compelled (or funded) to try. We perform comparisons with standard MODIS data, and discuss impacts of calibration, resolution, sampling, and whatever else seems important. Finally, we discuss our planned improvements for the DT algorithm, including our progress on estimating pixel-level error, correcting for urban surface optical properties, and retrieving close to clouds.

X.Liu

Impacts of wildfire aerosols from Southern Africa on stratocumulus clouds over Southeast Atlantic

Southern Africa is the world[1]s largest emitter of biomass burning aerosols. The westward transport of these wildfire aerosols over the remote Southeast Atlantic collocates with the Earth[1]s major subtropical stratocumulus decks occurring in the marine boundary layer. Wildfire aerosols such as black carbon (BC) and organic carbon (OC) can significantly perturb the properties of marine stratocumulus clouds through the microphysical effect (as CCN) and the radiative effect (as shortwave absorber); however, the relative importance of these two effects varies within 24 hours mainly due to the diurnal cycle of solar insolation. Given the fact that the strong diurnal cycles of stratocumulus clouds are also largely controlled by the solar insolation, the wildfire aerosols are very likely to exert an additional significant effect on the diurnal cycles of stratocumulus. To prove this hypothesis, we examine the roles of wildfire aerosols in observed diurnal cycles of stratocumulus clouds using the WRF-Chem model in conjunction with satellite observations. Wildfire aerosol emissions with high resolution are generated from fire radiative power values detected by SEVIRI onboard geostationary satellite Meteosat. The wildfire aerosols are treated as the internal mixture of OC, BC, and other inorganic components, and coupled with the microphysics and radiation schemes in WRF-Chem. We thoroughly compare the diurnal variations in modeled cloud properties, such as LWP and cloud fraction among 1) the case with both microphysical and radiative effects of wildfire aerosols (the reference case), 2) the case with only microphysical effect, and 3) the case with no wildfire aerosols. The differences in cloud properties are interpreted as the effects of wildfire aerosol. The wildfire aerosol, cloud, and radiation fields modeled by the reference case are validated against satellite observations, including MODIS aerosol optical depth, cloud fraction/LWP, CALIPSO aerosol-cloud overlapping frequency, and CERES radiative fluxes.

A.Lyapustin

Joint AOT-Single Scattering Albedo Retrieval in Algorithm MAIAC

Multi-Angle Implementation of Atmospheric Correction (MAIAC) is a new 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 C6+ re-processing of MODIS data record, scheduled to begin in November 2015, will create a suite of products MCD19. Due to high 1km resolution, MAIAC provides information about fine scale aerosol variability required in different applications such as urban air quality analysis. During the past year, we developed a new MAIAC capability to retrieve Single Scattering Albedo (SSA) from MODIS by adapting OMI heritage approach of O. Torres. We will describe MAIAC retrieval approach, AERONET AOT and SSA validation for different world biomass burning regions, and will compare MAIAC results with other sensors.

P.Lynch

Development Studies Towards An 11-year global gridded aerosol optical thickness reanalysis for climate and applied applications

While standalone satellite and model aerosol products see wide utilization, there is a significant need in numerous climate and applied applications for a fused product on a regular grid. Aerosol data assimilation is an operational reality at numerous centers, and like meteorological reanalyses, aerosol reanalyses will see significant use in the near future. Here we present a standardized 2003 - 2013 global 1x1 degree and 6-hourly aerosol optical thickness (AOT) reanalysis product. This dataset can be applied to basic and applied earth system science studies of significant aerosol events, aerosol impacts on numerical weather prediction, and electro-optical propagation and sensor performance, among other uses. This paper describes the science of how to develop and score an aerosol reanalysis product. This reanalysis utilizes a modified Navy Aerosol Analysis and Prediction System (NAAPS) at its core and assimilates quality controlled retrievals of AOT from the Moderate Resolution Imaging Spectroradiometer (MODIS) on Terra and Aqua and the Multi-angle Imaging SpectroRaditometer (MISR) on Terra. The aerosol source functions, including dust and smoke, were regionally tuned to obtain the best match between the model fine and coarse mode AOTs and the Aerosol Robotic Network (AERONET). Other model processes, including deposition and sea salt lifting, were tuned by minimizing the AOT difference between the model and satellite AOT. Aerosol wet deposition in the tropics is constrained with satellite retrieved precipitation. The final reanalyzed fine and coarse mode AOT at 550nm is shown to have good agreement with AERONET observations, with global mean root mean square error around 0.1 for both fine and coarse mode AOTs. This paper includes a discussion of issues particular to aerosol reanalyses that make them distinct from standard meteorological reanalyses, considerations for extending such a reanalysis outside of the NASA A-Train, and examples of how the aerosol reanalysis can be applied or fused with other model or remote sensing products. Finally, the reanalysis is evaluated in comparison with other available studies on aerosol trends, and the implications of this comparison are discussed.

P.L.Ma

A New Aerosol Lidar Simulator for Global Climate Models

We have developed a new aerosol lidar simulator to facilitate fair comparison of aerosols between global climate models (GCMs) and CALIPSO measurements. Mie scattering is performed to compute the extinction and the 180-degree aerosol backscatter by species, which is then used to compute the lidar attenuated backscatter (ATB) and signal ratio (SR). The simulator also identifies the types of aerosols using an algorithm similar to the algorithm used to produce the standard CALIPSO level-2 aerosol data product, which is based on the surface type, the height of the aerosol layer, SR, and the depolarization ratio. We have also created a new GCM-oriented CALIPSO Aerosol Product (GOCAP) for model-observation comparison using the same algorithms for cloud screening, noise elimination, and aerosol typing as those used in the simulator. Using nudged CAM5 simulations, we demonstrate that the simulator accounts for the sampling and algorithmic differences between models and observations,

making fair comparison possible. This new aerosol simulator and the corresponding new GOCAP dataset can be very useful for evaluating/constraining aerosol and aerosol-cloud-precipitation interactions in GCMs.

J.Mulcahy

Towards UKESM: Implementation and evaluation of the GLOMAP-Mode aerosol scheme

The next generation UK Earth System model (UKESM) is a joint development effort between the UK Met Office and the wider UK academic community supported through NERC (National Environmental Research Council). UKESM will build on the latest global coupled (GC) climate configuration of the Met Office Unified Model (MetUM) which describes the core physical-dynamical processes of the land, atmosphere, ocean and ice systems. For the 1st version of UKESM we will extend the physical-dynamical approach to also include key biogeochemical cycles and phenomena that may; (i) provide an important (amplifying or damping) feedback onto physical climate change and/or (ii) change themselves in response to changes in the physical climate and thereby impact society or natural ecosystems. Atmospheric aerosols are one important component of such an ES model due to their impacts on the radiation characteristics of the atmosphere (termed direct effects) and cloud and precipitation processes (termed indirect effects). Aerosols also interact with atmospheric chemistry and biogeochemical cycles in the atmosphere, ocean, and ice surfaces. However, aerosol distributions and in particular aerosol-cloud interactions remain one of the key uncertainties in the latest estimates of anthropogenic radiative forcing on climate. Improved representation of tropospheric chemistry-aerosol processes is therefore an integral part of the development of UKESM which will use the UKCA stratospheric-tropospheric chemistry and GLOMAP-mode aerosol microphysics schemes. Here we evaluate the performance of the latest configuration of GLOMAP-Mode in the latest Global Atmosphere (GA) configuration of the MetUM, as a step towards UKESM1. Aerosol microphysical and optical properties are evaluated against a wide-range of ground-based and satellite measurements. Impacts of the new scheme on key components of the physical model relative to its predecessor CLASSIC are also presented and discussed.

G.Mann

Evaluation of tropospheric aerosol properties from the UK Earth System Model against in-situ observations and multi-model ranges from the AeroCom aerosol microphysics intercomparison

We present results from ongoing evaluation activities to assess tropospheric aerosol properties in several reference simulations of the UM-UKCA composition-climate model. UM-UKCA is the

atmospheric chemistry-aerosol component of the new UK Earth System Model (UKESM) currently in development for CMIP6 and includes the GLOMAP aerosol microphysics scheme. An "evaluate suite" has been assembled to facilitate assessment of UK-UKCA simulated aerosol properties against benchmark observational datasets, previous reference model simulations and multi-model datasets from co-ordinated international modelling activities such as AeroCom. In this poster we focus on the analysis of speciated aerosol mass concentrations (sulphate, sea-salt, black carbon, particulate organic matter and dust) and size-resolved number concentations across a range of size-cuts, comparing to benchmark observation datasets and inter-model ranges from the AeroCom aerosol microphysics intercomparison (Mann et al., 2014). The UKESM will simulate atmospheric composition across the troposphere and stratosphere with also well resolved stratospheric dynamics and interactive stratospheric aerosol microphysics. The skill scores for a range of configurations on the model are presented, including previous UM-UKCA submissions to AeroCom and several configurations of the current latest version of the community composition-climate model being used by researchers in the UK University community.

The SSiRC Historical Eruption SO2 Emissions Assessment (HErSEA): intercomparison for interactive stratospheric aerosol models

Major historical volcanic eruptions have injected huge amounts of sulphur dioxide into the stratosphere with observations showing an enhancement of the stratospheric aerosol layer for several years (ASAP, 2006). Such long-lasting increases in stratospheric aerosol loading cool the Earth's surface by scattering incoming solar radiation reduce and warm the stratosphere via absorption of near infra-red solar and long-wave terrestrial radiation with complex effects on climate (e.g. Robock, 2000). Two recent modelling studies of Mount Pinatubo (Dhomse et al., 2014; Sheng et al. 2015) have highlighted that observations suggest the sulphur loading of the volcanically enhanced stratospheric aerosol may have been considerably lower than suggested by measurements of the injected SO2 (17-20MT). This poster describes a new model intercomparison activity for interactive stratospheric aerosol models within the framework of the SPARC initiative on Stratospheric Sulphur and its Role in Climate (SSiRC). The new 'Historical Eruption SO2 emissions Assessment' (HErSEA) will intercompare model simulations of the three largest volcanic perturbations to the stratosphere in the last 50 years, 1963 Mt Agung, 1982 El Chichon and 1991 Mt Pinatubo. The aim is to assess how effectively the emitted SO2 translates into perturbations to stratospheric aerosol properties and simulated radiative forcings in different types of interactive stratospheric aerosol composition-climate models (SA-CCMs). Each SA-CCM modelling group will run a mini-ensemble of transient AMIP-type runs for the 3 eruptions with a control no-eruption run followed by upper and lower bound injection amount estimates and 3 different injection height settings for two shallow (e.g. 19-21km amd 23-25km) and one deep (e.g. 19-25km) injection. First order analysis will intercompare stratospheric aerosol metrics such as 2D-monthly AOD (550nm, 1020nm) and timeseries of tropical and NH/SH mid-visible extinction at three different models levels (15, 20 and 25km). To allow the global variation in size distribution to also be intercompared, models will also diagnose 3D-monthly effective radius and N (with radii greater than 10nm, 150nm and 1000nm).
The mini-ensemble is designed to be straighforward to assess several historical major eruptions and will be a precursor to the larger perturbed parameter ensemble study of the Pinatubo eruption (PoEMS) which will more rigorously assess sources of uncertainty in volcanic forcings simulated by the different models.

Whole-atmosphere chemistry-aerosol-microphysics simulations of the Mt. Pinatubo eruption: Part 2: Quantifying the direct and indirect (dynamical) radiative forcings

The Mt Pinatubo volcanic eruption in June 1991 injected between 14 and 20 Tg of sulphur dioxide into the tropical stratosphere between about 21 and 28km altitude. Following chemical conversion to sulphuric acid, the stratospheric aerosol layer thickened substantially causing a strong radiative, dynamical and chemical perturbation to the Earth's atmosphere with effects lasting several years.
In this presentation we show results from model experiments to isolate the different ways the enhanced stratospheric aerosol from Pinatubo influenced the Earthâ€™s climate. The simulations are carried out in the UK Chemistry and Aerosol composition-climate model (UKCA) which extends the high-top (to 80km) version of the HadGEM3 climate model. The HadGEM3-UKCA model uses the GLOMAP-mode aerosol microphysics module coupled with a stratospheric chemistry scheme including sulphur chemistry. By running no-feedback and standard integrations, we separate the main radiative forcings due to aerosol-radiation interactions (i.e. the direct forcings) from those induced by dynamical changes which alter meridional heat transport and distributions of aerosol, ozone and water vapour.

L.Marshall

Disentangling the eruption source parameters that control the climate effects of volcanic eruptions

Climatic cooling associated with volcanic eruptions does not scale linearly with the mass of SO2 emitted into the atmosphere. Many other parameters such as the injection height, latitude, season, and atmospheric circulation such as the Quasi-Biennial Oscillation phase, can affect the magnitude of the climatic impact of an eruption. However, a fundamental understanding of the importance of each of these parameters and the magnitude of the climatic response has yet to be elucidated. Furthermore, there has been no systematic assessment of these relationships when considering aerosol microphysical processes. Model simulations are conducted using the UM-UKCA model to investigate the effect of eruption source parameters on aerosol properties and consequent climatic cooling. Parameters such as the SO2 mass injection, injection height, latitude, and season are subsequently systematically varied. Initial results demonstrate that aerosol optical depth and radiative flux anomalies do not scale linearly with increasing SO2 injection magnitude. Further exploration may consider other climatic and regional impacts such as precipitation changes. Results will help our understanding of the impact of past, present and future volcanism, and the feasibility of geoengineering techniques using SO2.

T.Michibata

Evaluation of Auto-conversion and Accretion Processes in the MIROC-SPRINTARS and Future Model Improvement

This study examines the performance of five auto-conversion schemes, which are commonly used in many GCMs. The sensitivity experiments were conducted within a single-model framework using an aerosol climate model, MIROC-SPRINTARS. The ratio of accretion to auto-conversion (Acc/Aut ratio), a key parameter of the balance of microphysical conversion processes, has a high sensitivity globally depending on the auto-conversion scheme used. Although the VOCALS observation indicated that the Acc/Aut ratio ranges from ~1 to ~100 in the work by Gettelman et al. (2013), the model predicts the ratio from ~0.01 to ~10.0. This means the relative role of the accretion process is one or more orders of magnitude underestimated compared to the observation due to the diagnostic treatment of rainwater in the model. The underestimation of cloud effective radius in a few μm is also found in the model, and this will lead biases; too bright low-cloud problem and overestimation of the shortwave cloud radiative forcing at the top of the atmosphere. The above issues are one of the common problems in many GCMs, and no auto-conversion schemes significantly improve them. We currently plan to apply the prognostic precipitation including drizzle in the updated version of MIROC-SPRINTARS to overcome the above issues.

M.Michou, P.Nabat, L.Watson and D.Saint-Martin

Recent evolutions of the aerosol scheme in the CNRM climate model, in view of CMIP6 simulations

The poster presents the recent evolutions of the parameterizations included in the aerosol scheme which is part of the CNRM climate model CNRM-CM6, such as those related to the sea salt emissions or the indirect effect of aerosols. Choices retained in view of the preparation of an in-house aerosol climatology for coming CMIP6 simulations are also shown.

T.Mielonen

Does Increasing Temperature Increase Carbonaceous Aerosol Direct Radiative Effect over Boreal Forests?

Aerosols are an important regulator of the Earth's climate. They scatter and absorb incoming solar radiation and thus cool the climate by reducing the amount of energy reaching the atmospheric layers and the surface below (direct effect). A certain subset of the particles can also act as initial formation sites for cloud droplets and thereby modify the microphysics, dynamics, radiative properties and lifetime

of clouds (indirect effects). The magnitude of aerosol radiative effects remains the single largest uncertainty in current estimates of anthropogenic radiative forcing. One of the key quantities needed for accurate estimates of anthropogenic radiative forcing is an accurate estimate of the radiative effects from natural unperturbed aerosol. The dominant source of natural aerosols over Earth's vast forested regions are biogenic volatile organic compounds (BVOC) which, following oxidation in the atmosphere, can condense onto aerosol particles to form secondary organic aerosol (SOA) and significantly modify the particles' properties. In accordance with the expected positive temperature dependence of BVOC emissions, several previous studies have shown that some aerosol properties, such as mass concentration and ability to act as cloud condensation nuclei (CCN), also correlate positively with temperature at many forested sites. There is conflicting evidence as to whether the aerosol direct effects have a temperature dependence due to increased BVOC emissions.
The main objective of this study is to investigate the causes of the observed effect of increasing temperatures on the aerosol direct radiative effect, and to provide a quantitative estimate of this effect and of the resulting negative feedback in a warming climate. More specifically, we will investigate the causes of the positive correlation between aerosol optical depth (AOD) and land surface temperature (LST) over boreal forests where biogenic emissions are a significant source of atmospheric particles . In addition to BVOCs, SOA formed in clouds and biomass burning emissions could also explain the temperature dependence of aerosol direct radiative effect. The study will be done using a combination of satellite data and climate modeling. Key remote sensing data used are the aerosol optical depth and land surface temperature AATSR products available from the Aerosol-CCI and GlobTemperature projects, together with ancillary data, such as column concentrations of CO and water vapour from AIRS, NO2 from OMI, and aerosol profiles from CALIOP, and ESA's Soil Moisture-CCI products. The aerosol-chemistry climate model to be used is ECHAM-HAMMOZ, which describes all known relevant atmospheric aerosol processes. It includes all the main atmospheric aerosol compounds as well as the interactive biogenic emission model MEGAN, which enables the simulation of the effects of temperature changes on atmospheric aerosol load. With these tools, we can estimate the significance of the negative feedback due to a warming-induced aerosol direct effect and specify the aerosol species contributing to it.

J.Mollard

Constraining aerosol optical properties in AeroCom models and HadGEM3-UKCA using AERONET and POLDER observations

One aim of AeroCom is to evaluate the ability of climate models using observations. However, the usefulness of constraints bought by observations of Aerosol Optical Depth (AOD) and Absorbing Aerosol Optical Depth (AAOD) has been hugely debated recently. They do not constrain individual aerosol species, and are also limited both spatially and temporally. Therefore they are not always indicative of regional aerosol characteristics, making a straight comparison between observations and models an imperfect concept. In this talk, we demonstrate a new method that simultaneously relates the Single Scattering Albedo (SSA) and AOD, and the SSA and Angstrom Exponent, in a consistent way for models and observations. Using AeroCom 2 models and AERONET and POLDER retrievals, we find that AERONET constrains only a small fraction of the space. Furthermore, we establish that variability in SSA decreases with increasing AOD, in a way that depends on the region and local aerosol emissions. By exploiting

those relationships in sensitivity studies with HadGEM3, we suggest that strongly absorbing black carbon aerosols and absorbing organic carbon aerosols are required to match observational constraints.

L.Mona

Aerosol typing – a key information

Aerosol typing is a key source of aerosol information. Depending on the specific measurement technique, aerosol typing can be used as input for retrievals or represents an output for other applications. Satellite measurements in recent years are providing valuable information about the global distribution of aerosol types, showing for example the main source regions and typical transport paths. Climatological studies of aerosol load at global and regional scales often rely on inferred aerosol type. There is still a high degree of inhomogeneity among satellite aerosol typing schemes, which makes the use different sensor dataset in a consistent way difficult. In order to improve satellite-derived aerosol information and to provide a more consistent long-term global aerosol type dataset, the AEROSAT (International Satellite Aerosol Science Network, aero-sat.org) identified aerosol typing as one of its high-priority activities. The main objectives to be achieved are:
- Reviewing the aerosol typing assumptions
- Harmonizing the nomenclature
- Harmonizing the procedures as far as suitable
This will have an impact on long-term perspectives, satellite validation, and accuracy.

O.Morgenstern

The Deep South Clouds & Aerosols project: Improving the modelling of clouds in the Southern Ocean region

Southern-Hemisphere climate projections are subject to persistent climate model biases affecting the large majority of contemporary climate models, which degrade the reliability of these projections, particularly at the regional scale. Southern-Hemisphere specific problems include cloud coverage over the Southern Ocean with satellite-based observations indicating that cloud occurrence in this region is substantially underestimated. This has consequences for simulated radiation balance, sea surface temperatures, sea ice cover and storm track positions. The Southern-Ocean and Antarctic region is generally characterized by an acute paucity of surface-based and airborne observations, further complicating the situation.
In recognition of this and other Southern-Hemisphere specific problems with climate modelling, the New Zealand Government has launched the Deep South National Science Challenge, whose purpose is to develop a new Earth System Model which amongst other features is not subject to very large radiative forcing problems associated with erroneous clouds. The plan is to conduct a campaign of targeted observations in the Southern Ocean region, leveraging off international measurement

campaigns in this area, and using these and existing measurements of cloud and aerosol properties to improve the representation of clouds in the nascent New Zealand Earth System Model. Observations and model development will target aerosol physics and chemistry, particularly sulphate, sea salt, and non-sulphate organic aerosol, its interactions with clouds, and cloud microphysics. The hypothesis is that the cloud schemes in most GCMs are trained on Northern-Hemisphere data characterized by substantial anthropogenic or terrestrial aerosol-related influences which are almost completely absent in the Deep South.

G.Myhre

AeroCom semi-direct aerosol effect intercomparison exercise

The semi-direct aerosol effect from absorbing aerosols, mainly from black carbon, is highly uncertain and likely to be strongly model dependent. To quantify the model diversity and uncertainty associated with the semi-direct aerosol effect we invite to a joint effort among global modelling groups within AeroCom. In the available studies of the semi-direct aerosol effect it is found to be strongly dependent on the atmospheric altitude of the black carbon. Different treatment of cloud formation is another key uncertainty and therefore highlights the need for a multi-model intercomparison. In the semi-direct intercomparison exercise it will be optional for the modelling groups to either run with prescribed black carbon fields or with emissions. To compare the semi-direct effect for models with black carbon emission with models of prescribed fields, we will perform double set of simulations with some selected models. Two sets of prescribed black carbon fields to investigate the importance of the black carbon atmospheric altitude will be made available for the modelling groups allowing to run with prescribed black carbon fields. The recently improved ways to quantify forcing is important for the possibility for quantification of the semi-direct effect. Double radiation call will be important for the calculations of the semi-direct effect and a description will be given. The output from the model simulations will follow standard monthly fields as for CMIP5/CMIP6. The presentation will give a brief overview of existing studies on the semi-direct effect and describe the proposed model intercomparison exercise.

P.Nabat

Evaluation of the CNRM-CM aerosol scheme using the associated regional climate model CNRM-RCSM

Aerosols show a high spatio-temporal variability, thus making it difficult to compare directly outputs from the aerosol scheme included in a global model at low resolution with ground-based or in-situ measurements. Moreover, global models cannot reproduce the real observed chronology without nudging. At CNRM, the global and regional climate models, namely respectively CNRM-CM and CNRM-RCSM, share the same computer codes, including the same aerosol scheme. Consequently, we have used the regional model CNRM-RCSM to evaluate our aerosol scheme, thus taking advantage of the

finer resolution and the lateral boundary forcing by the ERA-Interim reanalysis. In this study, we have focused on the Mediterranean region submitted to numerous and various aerosols, to evaluate more precisely the aerosol scheme. Amongst different observations, we have notably used measurements from the recent ChArMEx field campaign during summers 2012 and 2013. The dust scheme has been particularly studied given the important dust plumes present in the region coming from Saharan sources. The sea-salt scheme, as well as the decrease in sulfate aerosols since 1980, have also been evaluated.

D.Neubauer

Aerosol-cloud interactions in ECHAM6-HAM2 and the (A)ATSR dataset

The projects of the Climate Change Initiative (CCI) programme of ESA aim at producing long time series of satellite data of essential climate variables. A cooperation between the Aerosol_cci and Cloud_cci project gives the opportunity to produce dedicated products for aerosol-cloud interactions (ACI). ACI are quantified as susceptibilities and histograms of cloud properties from Cloud_cci to aerosol properties from Aerosol_cci (A)ATSR datasets. The susceptibilities are compared to susceptibilities from the aerosol climate model ECHAM6-HAM2 to get insights in the discrepancy between model based and satellite based estimates of ACI within the Aerosol_cci project.
Particularly interesting relationships for the cloud albedo effect and the cloud lifetime effect are investigated. As the resolution of the data can have an impact on statistical correlations between cloud and aerosol properties, susceptibilities and histograms of the satellite data are computed at high resolution and aggregated to a coarser resolution for analysis with an appropriate weighting method. Susceptibilities have been shown to depend on environmental conditions (stability of the atmosphere, relative humidity in free troposphere, precipitation state). In particular the precipitation state can change the sign of the susceptibilities. A first analysis showed discrepancies in the precipitation state dependency of the susceptibilities of ECHAM6-HAM2 and (A)ATSR.
Results will be presented at the workshop.

D.Olivie

SLCP emission reduction: how to simultaneously improve air quality and limit climate change?

Short-lived climate pollutants (SLCPs) are gases and particles from anthropogenic origin and with a short atmospheric lifetime that can affect both air quality and climate, e.g., ozone and aerosols. Reducing their emissions (or of their precursors) will improve the air quality, but might either reduce or increase climate impacts. Cost-effective emission reduction measures should be chosen such that they optimize both the climate and air quality responses. An emission mitigation scenario (MIT) for short-lived climate pollutants focusing on simultaneously improving air-quality and limiting climate change has been

developed within the ECLIPSE project for the near future (2015--2050). This was done in addition to a current-legislation emission scenario (CLE) developed for the same time period. Using these two scenarios, the year 2005--2050 period has been simulated with three atmosphere-ocean general circulation models (AOGCMs), i.e., HadGEM3, ECHAM6, and NorESM1, and one chemistry transport model (OsloCTM2). With each AOGCM an ensemble of three members for both scenarios (CLE and MIT) has been run, while with OsloCTM2 time-slice experiments have been performed. In the analysis presented here, we focus on the impact on air quality and look at surface concentrations of ozone and aerosol (PM2.5) when implementing air quality measures weighted by their climate impact.

N.Oshima

Impact of black carbon aging on its spatial distribution and radiative effect using a MRI global aerosol model

A new parameterization of black carbon (BC) aging, which enables the representation of spatial and temporal variations of the conversion rate from hydrophobic BC to hydrophilic BC, has recently been developed using a size and mixing state resolved aerosol box model (MADRID-BC). In this study, we apply the parameterization to the Model of Aerosol Species IN the Global Atmosphere (MASINGAR-mk2), which is included in the earth system model of the Meteorological Research Institute (MRI-ESM1), to evaluate the impact of the BC aging on its spatial distribution and radiative effects. The model calculation with the parameterization shows that the conversion timescales from hydrophobic BC to hydrophilic BC exhibit distinct spatial variations. Their annual averages are approximately half a day and one week over East Asia (source regions) and the Arctic (remote regions), respectively. Comparisons with the calculation using the constant conversion rate (1.2 days, used in the original approach) show that both calculations reproduce the seasonal variations of BC mass concentrations observed by the surface measurements reasonably well over East Asia. On the other hand, although the constant-rate calculation largely underestimates the BC mass concentrations observed over the Arctic, the use of the parameterization improves the concentration levels and reproduces the seasonal variations. The direct radiative forcing by BC (annually and globally averaged at the top of atmosphere) is estimated to be 0.23 W m-2 for the calculation with the parameterization (0.20 W m-2 for the constant-rate calculation). These results indicate that the aging process of BC in the micro-scale can significantly impact on its spatial distribution and radiative forcing in the global-scale.

X.Pan

Comparison of GFED, QFED and FEER biomass burning emissions datasets in a global model

Biomass burning contributes about 40% of the global loading of carbonaceous aerosols, significantly affecting air quality and the climate system by modulating solar radiation and cloud properties. However, fire emissions are poorly constrained in models on global and regional levels. In this study, we investigate 3 global biomass burning emission datasets in NASA GEOS5, namely: (1) GFEDv3.1 (Global Fire Emissions Database version 3.1); (2) QFEDv2.4 (Quick Fire Emissions Dataset version 2.4); (3) FEERv1 (Fire Energetics and Emissions Research version 1.0. The simulated aerosol optical depth (AOD), absorption AOD (AAOD), Ångström exponent and surface concentrations of aerosol plumes dominated by fire emissions are evaluated and compared to MODIS, OMI, AERONET, and IMPROVE data over different regions. In general, the spatial patterns of biomass burning emissions from these inventories are similar, although the strength of the emissions can be noticeably different. The emissions estimates from QFED are generally larger than those of FEER, which are in turn larger than those of GFED. AOD simulated with all these 3 databases are lower than the corresponding observations in Southern Africa and South America, two of the major biomass burning regions in the world.

F.Patadia

Pixel Level Uncertainty in Aerosol Optical Depth Retrieved By MODIS Dark Target Algorithm

We now have a record of nearly 15 years of Aerosol optical depth (AOD) retrieved by the Moderate Resolution Imaging Spectrometer (MODIS) Dark Target (DT) algorithm. The MODIS DT team and several other independent studies have evaluated the AOD by direct comparison with the AOD reported by ground-based sun photometers. The result has been a rigorous “validation” of the DT products. Global validation of the current Collection 6 (C6) AOD over ocean indicate that 68% of retrieved AOD agrees within 0.03 ± 10% * AERONET AOD. However, validation does not tell a user anything about specific aerosol retrieval cases. Therefore, our team is taking the next logical step and developing the framework for deriving per-pixel retrieval uncertainty. The retrieval uncertainty in AOD comes from (1) non-linearity the algorithm’s look-up-table approach and (2) various assumptions made prior to and during the retrieval. Some of these assumptions include errors in the observed reflectance (calibration or missing data), standard deviation of the reflectance over the retrieval box, non-aerosol (e.g. gas absorption and Rayleigh) atmospheric corrections, and characterization of the surface reflectance. We will discuss the methodology of our framework and present a year’s worth of global and regional analysis of the uncertainty our AOD retrievals.

F.Paulot

Sensitivity of nitrate aerosols to ammonia emissions and to nitrate chemistry: implications for present and future nitrate optical depth

Nitrate aerosol will become an increasingly important contributor to the anthropogenic aerosol optical depth during the second half of the 21st century. However, the simulation of nitrate aerosol present unique challenges and there is no model consensus on the present-day nitrate optical depth. Here, we will present simulations that assess the sensitivity of nitrate optical depth to uncertainties in the heterogeneous production and loss of nitrate and in the diurnal and seasonal variations of ammonia emissions under both present-day emissions and future emissions. Based on these simulations, we propose an experiment to assess how changes in the spatial distribution of ammonia emissions may modulate the transport of ammonia to the free troposphere and the formation of nitrate aerosols in this region of the atmosphere.

H.Pearce

Nitrate Aerosol: Implications for European Air Quality and Climate Development

Nitrate aerosol has become an important driver of European climate effects and air quality, following reductions in sulphate precursor emissions since the 1980s, and is expected to be more influential in future decades. Furthermore, measurements from the EUCAARI field campaign have shown that semi-volatile aerosol species such as ammonium nitrate can comprise a major component of the sub-micron particulate matter, particularly in high pollution episodes. However, the treatment of nitrate in global model simulations is often heavily simplified or omitted as the partitioning of semi-volatile gas phase species into the particle phase is complex and computationally expensive. We will investigate the effects of nitrate on European air quality and climate using the UM-UKCA composition-climate model including a recently developed 'hybrid' partitioning module that is physically realistic and also computationally efficient. We will present preliminary results from an analysis of simulated size-resolved composition variations through the EUCAARI campaign time period.

M.Petrenko

AEROCOM Biomass Burning experiment: constraining model aerosol emission amount with satellite data

Biomass burning (BB) is one of the major sources of optically and chemically potent carbonaceous aerosols, gaseous aerosol precursors, and volatile organic compounds. It is, therefore, important to represent these emissions as accurately as possible in the global and regional models. Based on our method of using satellite snapshot of aerosol optical depth (AOD) to constrain biomass burning emissions in the Goddard Chemistry Aerosol Radiation and Transport (GOCART) model (Petrenko e t al., JGR 2012), we now present key refinements and applications of this method.
We will present a reference dataset of biomass burning cases constructed specifically for this project,

initial findings from comparing total AOD and BB AOD between the models and with the reference satellite dataset, and mention future directions of this project. We will also showcase our approach for treating AOD snapshots to be suitable for comparison with the global models, and its potential applications to other BB-related projects.

T.Popp

Aerosol CCI achievements

- IASI round robin
- Comparing different types of retrieval (IASI, MISR, POLDER)
- Aerosol type – what can we retrieve (fine mode, …)
- Planned round ribbon exercises (layer height, absorption)

A.Povey

The application of ensemble techniques to uncertainty estimation in satellite remote sensing data

A discussion of best-practice representation of uncertainty in satellite remote sensing data. An estimate of uncertainty is necessary to make appropriate use of the information conveyed by a measurement. Traditional error propagation quantifies the uncertainty in a measurement due to well-understood perturbations in a measurement and auxiliary data --- known, quantified `unknowns'. The underconstrained nature of most satellite remote sensing observations requires the use of various approximations and assumptions that produce non-linear systematic errors that are not readily assessed --- known, unquantifiable `unknowns'. Additional errors result from the inability to resolve all scales of variation in the measured quantity --- unknown `unknowns'. The latter two categories of error are dominant in underconstrained remote sensing retrievals and the difficulty of their quantification limits the utility of existing uncertainty estimates, degrading confidence in such data. We propose the use of ensemble techniques to present multiple self-consistent realisations of a data set as a means of depicting unquantified uncertainties. These are generated using various systems (different algorithms or forward models) believed to be appropriate to the conditions observed. Benefiting from the experience of the climate modelling community, an ensemble provides a user with a more complete representation of the uncertainty as understood by the data producer and greater freedom to consider different realisations of the data.

J.Quaas

The Aerosols-Clouds-Precipitation-and-Climate (ACPC) initiative

The Aerosols-Clouds-Precipitation-and-Climate (ACPC) initiative, jointly supported by GEWEX and iLEAPS, entered a new phase last year. Following the results from the previous phase (Rosenfeld et al., Rev. Geophys. 2014), it now explores the idea of a large-scale field experiment that would aim at characterising the aerosol perturbation of water- and energy budgets at the scale of a climate model column. To this end, large-domain, interactive-aerosol, cloud-resolving simulations for shallow- and deep cloud cases are explored. In the presentation I would like to introduce ACPC and explain my view on is complementarity to AEROCOM.

C.Randles

The Modern-Era Retrospective analysis for Research and Applications, Version 2: The Goddard Aerosol Assimilation System Aerosol Reanalysis 1979 — Present

The Modern-Era Retrospective analysis for Research and Applications, Version 2 (MERRA-2) was undertaken by NASA's Global Modeling and Assimilation Office (GMAO) with two primary objectives: to place observations from NASA's Earth Observing System (EOS) satellites into a climate context and to update the Modern-Era Retrospective analysis for Research and Applications (MERRA) system to include the most recent satellite data. Numerous advancements have been incorporated into the MERRA-2 system, such as an improved balance between precipitation and evaporation and a reduction of the impact of a changing observing system on the analysis. Of relevance to this presentation, and as a significant step towards an Integrated Earth System Analysis (IESA), MERRA-2 now includes fully modeled and analyzed aerosol fields, with radiative effects that feed back to the atmospheric. Focusing on the satellite era, from 1979 to the present, MERRA-2 uses an online implementation of the Goddard Chemistry, Aerosol, Radiation, and Transport model (GOCART) integrated into the Goddard Earth Observing System Model, Version 5 (GEOS-5) modeling system. GOCART simulates organic carbon, black carbon, sea salt, dust, sulfate and sulfate aerosol precursors (dimethyl sulfide, sulfur dioxide), carbon monoxide and carbon dioxide. While the original MERRA assimilated only meteorological parameters (winds, temperature, humidity, etc.), with the Goddard Aerosol Assimilation System (GAAS), we now extend MERRA-2 to include assimilation of bias-corrected Aerosol Optical Depth (AOD) retrievals from AVHRR, MODIS, MISR (over bright surfaces), and AERONET. Here we present an overview of the MERRA-2 aerosol assimilation product, including an assessment of its overall performance relative to numerous independent aerosol observations from remote sensing platforms, ground-based stations, and aircraft. We also present the overall climatology and time series of AOD from 1979 - present, and we explore the impact of major volcanic eruptions (e.g. Pinatubo) on the analyzed aerosol fields.

A.Rap

Impact of biomass burning aerosol on Amazon plant productivity through changes to diffuse radiation

Atmospheric aerosol scatters solar radiation increasing the fraction of diffuse radiation and the efficiency of photosynthesis. We quantify the impacts of biomass burning aerosol (BBA) on diffuse radiation and plant photosynthesis across the Amazon basin during 1998–2007. Evaluation against observed aerosol optical depth allows us to provide lower and upper BBA emissions estimates. Our methodology is based on the combined use of three models: (i) the Global Model of Aerosol Processes (GLOMAP), (ii) the Edwards-Slingo radiation model, and (iii) the UK Met Office JULES land-surface scheme, constrained against in-situ aerosol, radiation and gross primary productivity (GPP) observations from several Amazonian sites. A 10 year (1998-2007) GLOMAP simulation using GFED3 biomass burning emissions is first evaluated against aerosol measurements, indicating that the model is able to capture the Amazon aerosol seasonality, with enhanced concentrations during the dry season driven by biomass burning. The radiation scheme is then shown to be in good agreement with total and diffuse radiation in-situ observations, the model being able to capture the high total and low diffuse radiation flux in the dry season, as well as the low total and high diffuse radiation flux in the wet season. We then use our modelling framework to quantify the contribution of biomass burning emissions to diffuse/direct radiation fraction and forest productivity. BBA increases Amazon basin annual mean diffuse radiation by 3.4–6.8% and net primary production (NPP) by 1.4–2.8%, with quoted ranges driven by uncertainty in BBA emissions. The enhancement of Amazon basin NPP by 78–156 Tg C a−1 is equivalent to 33–65% of the annual regional carbon emissions from biomass burning. This NPP increase occurs during the dry season and acts to counteract some of the observed effect of drought on tropical production. We estimate that 30–60 Tg C a−1 of this NPP enhancement is within woody tissue, accounting for 8–16% of the observed carbon sink across mature Amazonian forests.

M.Righi, V. Eyring, J. Hendricks, C. Kaiser and ESMValTool Development Team

Aerosol evaluation with the Earth System Model eValuation Tool: A community diagnostic and performance metrics tool.

A community diagnostics and performance metrics tool for routine benchmarking and process evaluation of Earth System Models (ESMs) has been developed that allows the comparison of single or multiple models to predecessor versions or to observations. The Earth System Model eValuation Tool (ESMValTool, http://www.pa.op.dlr.de/ESMValTool/) is developed as a community system that is easy to extend with additional diagnostics, open to both users and developers, hence encouraging the exchange of evaluation methods and results. The ESMValTool includes process- and phenomena-based diagnostics and metrics and evaluates the climate state and its variability in addition to selected atmospheric, biogeochemical, ocean and sea-ice processes. Here we present the aerosol diagnostic capabilities of ESMValTool (v1.0), which can be used to evaluate model-simulated aerosol surface-level concentrations against station data, aerosol optical depth against station data and satellite observations, as well as vertical profiles of aerosol mass and number concentration against aircraft measurements.

ESMValTool (v1.0) is able to deal with a wide variety of observational datasets from different sources, including EMEP, EANET, IMPROVE, CASTNET, AERONET, MODIS, MISR, ESACCI-AEROSOL and several aircraft campaigns like HIPPO. ESMValTool (v1.0) is being primarily developed for the evaluation of the upcoming CMIP6 models, but it is designed in a very flexible way so that it can be applied to individual models and to models from other model intercomparison projects, such as AEROCOM and CCMI. The aerosol community is encouraged to join this effort by contributing innovative analysis codes for a more routine and broad evaluation of aerosol models and a better process understanding.

S.Rumboldt

Ammonium nitrate aerosol in UKESM1

Ammonium nitrate is of increasing importance in climate simulations both in terms of radiative forcing and air quality. A modal ammonium nitrate aerosol scheme is being incorporated into UKESM1 in preparation for CMIP6. The GLOMAP ammonium nitrate scheme is significantly more advanced than the HadGEM2-ES CLASSIC scheme used for CMIP5. The addition of the dissolution code not only provides nitrate aerosol, but will provide UKCA-GLOMAP with increased fidelity. The dissolution code considers the two-way interaction with the surrounding gas in addition to the particles themselves (i.e the code will represent a true aerosol). Furthermore, rather than representing neutral substances as in the existing UKCA-GLOMAP code, ions will now be considered (e.g. separate sodium and chloride ions instead of “sea salt”). The GLOMAP dissolution code has proven to be very sensitive to the host model environment. In particular, the free-running atmosphere of UKCA-GLOMAP (HadGEM3) provides more situations for the code to become unstable than is the case with the TOMCAT offline chemical transport model. This poster serves as a status update for ammonium nitrate implementation in UKESM1.

B.Samset

Humidity in AeroCom Phase II: Comparisons to observations and consequences for radiative forcing

Humidity is an important factor for climate model calculations, affecting a range of physical phenomena including atmospheric radiative transfer and aerosol hygroscopic growth. Recently, specific humidity in the CMIP5 model ensemble was evaluated against AIRS and MERRA (Tian et al. 2013, JGRA), and a number of significant mode biases identified. In this talk, we compare geographical, vertical and temporal differences in the humidity fields calculated or used by the AeroCom Phase II models. We compare to CMIP5 results and satellite observations, and to Pacific vertical water profiles from the HIPPO campaigns 1-5. Using a radiative transfer code (DISORT), we explore the impact of intermodel differences in vertical humidity profiles on the AeroCom ensemble radiative forcing from the direct aerosol radiative effect.

M.Sand

Aerosols at the poles

Modeling of the climate impact of aerosols and clouds is at present plagued by uncertainties and inter-model differences. This is true on a global scale, end even more so for remote regions. Here we present aerosol burdens and radiative forcing at high latitudes from 15 detailed global aerosol models in the AeroCom phase II model inter-comparison project. The models have reported total aerosol radiative forcing due to anthropogenic aerosols, as well the individual aerosol species; black carbon, sulfate, organic carbon, nitrate, secondary organic aerosols, biomass burning aerosols, dust, and sea-salt. We present results from the inter-comparison with the goal of documenting the seasonal cycle of aerosol burdens and radiative forcing with a bi-polar perspective.

A.Sayer

Deep Blue aerosol updates in 2015

Since the last AEROCOM meeting, progress has been made on several fronts in the Deep Blue aerosol project. The MODIS Terra Collection 6 data record has been validated, and found to be stable throughout the mission to date, with quality almost as high as that of MODIS Aqua. Additionally, the first version of the VIIRS Deep Blue data set, combining Deep Blue over land with an over-water algorithm, will be released soon. This presentation will discuss both of these accomplishments.

N. Schutgens

Will perfect models agree with perfect observations?

Global aerosol models and observations differ strongly in their spatio-temporal sampling. Model results are typical of large gridboxes (200 by 200 km), while observations are made over much smaller areas (e.g. 10 by 10 km for MODIS, even smaller for ground sites). Model results are always available in contrast to observations that are intermittent due to orbital constraints, retrieval limitations and instrument failure/maintenance. These twin issues of temporal and spatial sampling are relevant for any observation, be it remotely sensed, or in-situ. We ask this question: will a perfect model agree with perfect observations? The short answer is: unlikely. Using two different modelling frame-works (year-long global model runs collocated with actual observations and month-long high resolution regional models runs) we show that significant errors can be introduced in a model to observation comparison due to different spatio-temporal sampling. These sampling errors are typically larger than observational

errors and are of comparable size as true model errors. While the temporal sampling issue can be dealt with by properly resampling model data to observation times, the spatial sampling issue introduces noise into the comparison. We propose and evaluate several strategies for mitigating this noise. The most successful strategy is further temporal averaging of the data. However, this seems to have a less beneficial effect on surface in-situ observations than on remotely sensed column-integrated measurements. Monthly averaged black carbon mass concentrations measured at ground sites still allow significant (~ 30%) noise into the comparison. Furthermore, flight campaign data, by its nature, are not open to long-term (monthly, yearly) averaging and allow sampling errors of 50% or more in black carbon mass concentrations. Other observables (AOT, extinction profiles, number densities, PM2.5, CCN) will also be discussed.

Comparing apples and oranges: the Community Intercomparison Suite

Visual representation and comparison of geoscientific datasets presents a huge challenge due to the large variety of file formats and spatio-temporal sampling of data (be they observations or simulations). The Community Intercomparison Suite attempts to greatly simplify these tasks for users by offering an intelligent but simple command line tool for visualisation and colocation of diverse datasets. In addition, CIS can subset and aggregate large datasets into smaller more manageable datasets. Our philosophy is to remove as much as possible the need for specialist knowledge by the user of the structure of a dataset. The colocation of observations with model data is as simple as: "cis col <native observation files> <variable name>:<native simulation files>:<options>" which will resample the simulation data to the spatio-temporal sampling of the observations, contingent on a few user-defined options that specify a resampling kernel.CIS can deal with both gridded and ungridded datasets of 2, 3 or 4 spatio-temporal dimensions. It can handle different spatial coordinates (e.g. longitude or distance, altitude or pressure level). CIS supports both HDF, netCDF and ASCII file formats. The suite is written in Python with entirely publicly available open source dependencies. Plug-ins allow a high degree of user-moddability. A web-based developer hub includes a manual and simple examples. CIS is developed as open source code by a specialist IT company under supervision of scientists from the University of Oxford and the Centre of Environmental Data Archival as part of investment in the JASMIN superdatacluster facility.

X.Shi

Effect of vertical fluctuations on estimating the anthropogenic aerosol indirect effects through cirrus clouds

Air parcel model driven by observed vertical velocity is used to study the effects of vertical fluctuations on cirrus formation. Parcel model statistical ensemble results show that, as compared to constant updraft velocity, homogeneous nucleation occurrence frequency is decreased from 25.0% to 1.1% if considering vertical fluctuations. As a result, Community Atmosphere Model (CAM5) model simulations show that anthropogenic aerosol indirect effects through cirrus clouds are significantly overestimated if the effect of vertical fluctuations is neglected.

J.Schwarz

Measurements of black carbon (BC) vertical profiles

We present Single Particle Soot Photometer measurements of black carbon (BC) vertical profiles over North America, Europe, the Arctic, and the outflow region of Saharan Africa before and after trans-Atlantic transport. Data, collected from 2011 to 2013, extend and strengthen constraints on the global abundance of BC. The data show that zonal mixing of BC becomes highly effective starting at 500 hPa and extending to near the tropopause. The concentration of BC in the upper troposphere can vary by a factor 10, but is consistent to a fraction of this range over month-long timescales. Regional vertical BC profiles support an existing narrative of global model (AeroCom) and sunphotometer (AeroNet) performance, except in the Arctic, where a high model bias (factor 3) was observed that was not realized earlier. These results reveal global-scale features of BC vertical profile that will help separate model representations of vertical transport/mixing and BC removal.

T.Shepherd

The climate impact of past changes in halocarbons and CO2 in the tropical UTLS region

A chemistry-climate model coupled to an ocean model is used to compare the climate impact of past (1960,Äì2010) changes in concentrations of halocarbons with those of CO2 in the tropical upper troposphere and lower stratosphere (UTLS). The halocarbon contribution to both upper troposphere warming and the associated increase in lower stratospheric upwelling is about 40% as large as that due to CO2. Trends in cold-point temperature and lower stratosphere water vapor are positive for both halocarbons and CO2, and are of about the same magnitude. Trends in lower stratosphere ozone are negative, due to the increased upwelling. These increases in water vapor and decreases in lower stratosphere ozone feed back onto lower stratosphere temperature through radiative cooling. The radiative cooling from ozone is about a factor of two larger than that from water vapor in the vicinity of the cold-point tropopause, while water vapor dominates at heights above 50 hPa. For halocarbons this indirect radiative cooling more than offsets the direct radiative warming, and together with the adiabatic cooling accounts for the lack of a halocarbon-induced warming of the lower stratosphere. For CO2 the indirect cooling from increased water vapor and decreased ozone is of comparable magnitude to the direct warming from CO2 in the vicinity of the cold-point tropopause, and (together with the increased upwelling) lowers the height at which CO2 increases induce stratospheric cooling, thus explaining the relatively weak increase in cold-point temperature due to the CO2 increases. We

S.Shim

Climate Effects of Aerosol-Cloud Interactions over East Asia

In this study, the climate feedbacks due to aerosol-cloud-radiation interaction are investigated during the late century using climate model HadGEM2-AO developed UK Met Office, a detailed description of the model is provided in Collins et al (2011). We perform some model simulation to evaluate anthropogenic forcing impacts on climate change during 20th century over East-Asia. For control run (CONT), pre-industrial simulation of Baek et al (2013) is used, which is prescribed, with aerosol emissions and GHGs concentration fixed at 1860 levels. To identify aerosol impact, single forcing experiment of GHGs (GHGS) is performed based on identical set-up of CONT, except for including time-varying GHG value is Jones et al (2011) for the CMIP5 historical simulation. In a similar way, aerosol (AERO) single forcing experiment is carried out. Aerosol emissions over East Asia increase rapidly in the second half of the 20th century because of the industrial revolution and population growth. In the early 20th century, total AOD is mostly attributed to natural particles such as sea-salt. Later, anthropogenic aerosol such as sulfate is the dominant component accounting for about 50% of total AOD. An increased amount of Aerosols might increase the CCN number concentration and lead to more, but smaller, cloud droplets for fixed liquid water contents. This effect called the cloud lifetime effect may enhance the cloud cover, with a persistent positive correlation between cloud cover and AOD. Particularly, aerosols have an influence on the amount of cloud cover (SC, ST, and NS), low-level clouds. On the other hand, GHGS could not find distinct change in spatial distribution for each cloud type in early and late 20th century. Consequently, these direct and indirect effects of aerosol affect radiative forcing to cause climate change over East Asia. Aerosol direct effect (clear-sky) is very similar to the distribution of total AOD change and is concentrated on Southeast China, whereas the cloud radiative effect (cloudy-sky) is dominant in ocean (higher than 30 degrees latitude). Very large CRF in the East Asian ocean (AERO) is caused by increase of Stratocumulus (SC) that is mostly distributed in the Korean and Japanese seas. More detailed analysis will be shown at the conference.

S.Smith

CEDS - New Historical Emissions for Aerosol and Chemistry Research

Historical emission estimates for anthropogenic aerosol and precursor compounds are key data needed for Earth system models, climate models, and atmospheric chemistry and transport models; both for general analysis and assessment and also for model validation through comparisons with observations. The CEDS (Community Emissions Data System) project will construct a data-driven, open source framework to produce annually updated emission estimates for aerosol and chemistry research. The goal of this system is to consistently extend current emission estimates both forward in time to recent years and also back over the entire industrial era. The project will produce improved datasets for global and (potentially) regional models, allow analysis of trends across time, countries, and sectors of emissions and emission factors, and facilitate improved scientific analysis in general. Consistent estimation of uncertainty will be an integral part of this system. This effort will facilitate community

evaluation of emissions and further emission-related research more generally. The first product from this project will be an updated historical emissions dataset for use in CMIP6.

L.Sogacheva, P. Kolmonen, T.H. Virtanen, E. Rodriguez, G. Saponaro, A.-M. Sundström and G. de Leeuw

Cloud post-processing for the ADV/ASV AATSR aerosol retrieval algorithm: regional aspects

The ATSR Dual View (ADV) and ATSR Single View (ASV) aerosol retrieval algorithms have been developed for use with the European Space Agency (ESA) Along Track Scanning Radiometers: ATSR-2 (1995-2003) and AATSR (2002-2012). The ATSR instruments provide the radiances at the TOA (top of the atmosphere) in 7 wavebands from the visible (VIS) to the thermal infrared (TIR) for two views: near-nadir and at 55 degrees forward. The dual view capability allows for elimination of the surface reflectance by using the k-ratio, which is the ratio of measured reflectance in the forward and nadir views in the 1.6 μm band, assuming that the effect of aerosols on the TOA reflectance is small at this wavelength. The basic principle of the aerosol retrieval is to match ATSR measured top of atmosphere (TOA) reflectance to modeled reflectance. The modeled reflectance is computed by applying a radiation transfer code for the solar radiance through the atmosphere. In the radiation transfer equation a model for the local aerosol is needed. Cloud screening is needed as the aerosol properties can be retrieved only for cloud-free sky. The (A)ATSR wide spectral range allows for effective cloud screening. However, not all cloud pixels are rejected with the cloud screening currently applied in ADV/ASV and additional cloud post-processing is needed. For each AOD-retrieved pixel, two tests are applied to determine and discard the pixels that might potentially include cloud edges or residual sub-pixel clouds. Each pixel is analyzed together with the eight surrounding pixels in a 0.3° × 0.3° area. If, in addition to the tested pixel, less than three pixels are retrieved in the area, the tested pixel is considered as a cloud edge and discarded. If, besides the tested pixel, at least three more pixels are retrieved and the standard deviation of the AOD in the area is larger than 0.1, the tested pixel is discarded. The value of the standard deviation equal to 0.1 is a compromise between global coverage and acceptable validation results. It has been used for producing AOD global datasets in the Aerosol_cci ESA project. However, for certain areas with high AOD (e.g. India, China), and for case studies of natural high AOD episodes (e.g. dust storms, volcanic eruptions) different values need to be used to obtain credible results. In the current presentation we introduce the results for cloud post-processing thresholds for high AOD loading episodes and areas and show the influence of the thresholds chosen on AOD mean values and AOD time series.

P.Stier

AeroCom Radiative Forcing Working Group &

AeroCom Experiment on Aerosol Effects on Convection

Limitations of passive satellite remote sensing to constrain global cloud condensation nuclei

Aerosol–cloud interactions are considered a key uncertainty in our understanding of climate change. Knowledge of the global abundance of aerosols suitable to act as cloud condensation nuclei is fundamental to determine the strength of the anthropogenic climate perturbation. Direct measurements are limited and sample only a very small fraction of the globe so that remote sensing from satellites and ground based instruments is widely used as a proxy for cloud condensation nuclei. However, the underlying assumptions cannot be robustly tested with the small number of measurements available so that no reliable global estimate of cloud condensation nuclei exists.

T.Takemura

Integrated assessment on effects of short-lived climate pollutants (SLCPs) in Asia

Air pollution over the Asian region is a serious social problem. Our Japanese research project is investigating an optimum reduction path of short-lived climate pollutants (SLCPs) as integrating all of climate change, health impacts, and agricultural damages. In this project, aerosol and chemistry climate models, SPRINTARS and CHASER, respectively, coupled with a general circulation model, MIROC, are used. In the phase 1 of this project, changes in concentrations and radiative forcing of each major SLCPs originating from China, East Asia, Southeast Asia, and South Asia in the last 30 years are estimated with the models. Transient simulations along the new emission scenario, SSPs (Shared Socio-economic Pathways) will be executed using the MIROC-SPRINTARS/CHASER with ocean circulation in the phase 2 to analyze full feedbacks including hydrological cycle affected by SLCPs. These simulated results will be utilized to estimate health and agricultural impacts of SLCPs and then to make inventories and scenarios with the optimum reduction path. In this presentation, the other recent studies related to SPRINTARS are also introduced including simulations on some model intercomparison studies.
Acknowledgements: Simulations in this study were executed with the supercomputer system of the National Institute for Environmental Studies, Japan. This study is partly supported by the Environment Research and Technology Development Fund (S-12-3) of the Ministry of the Environment, Japan and JSPS KAKENHI Grant Number 15H01728 and 15K12190.

Q.Tan, M. Chin, H. Bian and V. Aquila

Evaluation of modeled SO2 in the UTLS region with both satellite and aircraft data

Both ground based and satellite based measurement showed stratospheric aerosols exhibit some trend in the post Pinatubo era. Various reasons have been proposed to explain this observation. We evaluate the global aerosol model simulation in the UTLS region with multiple observation datasets with a focus on SO2, the important aerosol precursor. Both online and offline versions of GOddard Chemistry Aerosols Radiation Transport (GOCART) model, which is driven by NASA Goddard Earth Observing System Model Version 5, i.e. GEOS-5, meteorological condition are used in this evaluation. When compared to available satellite retrieval of SO2. GOCART model is able to capture the volcanic SO2's magnitude and variation in the UTLS region in general. We further compare the GOCART results with in-situ SO2 measurement from various aircraft campaigns in the recent decades. Sparse SO2 measurements in the UTLS region show significant temporal and spatial variations. Model simulation with different emission inputs, spatial resolution, SO2 in-cloud vertical transport and chemistry parameterization all contribute to significant model variations.

C.Timmreck, Davide Zanchettin, Myriam Khodri and Graham Mann

Towards a coordinated modeling assessment of the climate response to stratospheric aerosol

Our current understanding of the climatic response to stratospheric aerosol forcing is limited as large uncertainties affect both the observational records, due to the limited number of observations, and the non-robust dynamical responses simulated by different climate models.
The lack of agreement between model results is crucially determined by differences in models' characteristics such as resolution, complexity and implementation strategy of the forcing, and uncertainty in the eruption details including magnitude, latitude and season, input data and background climate as well as uncertainties n aerosol microphysics and transport. The multiple and varied nature of these factors prevents their contribution to uncertainty from being distinguished within existing transient simulations or non-coordinated multi-model experiments. For this reason, current international model intercomparison activities have chosen to design experiments to focus separately on the two major aspects linking volcanic sulfur emissions and the climate response. First, the steps from SO2 injection to effective radiative forcing including the chemical conversion to sulfate aerosols, microphysical transformations and dynamical responses of the stratospheric aerosol cloud; and second, the climate response to the radiaitive forcing including feedbacks in the coupled ocean-atmosphere system. For the first part the SPARC Stratospheric Sulfur and its Role in Climate Initiative (SSiRC) has established a model intercomparison activity for global aerosol models which simulate stratospheric aerosol interactively (SSIRCMIP). Two experiments aim to understand the quiescent stratospheric aerosol and the radiative forcing from the post-2000 increase in stratospheric aerosol. Two more focus on the intercomparison of simulated effective radiative forcings from major historical eruptions with an "SO2 emission assessment experiment" for Agung, El Chichon and Pinatubo, potentially linked to CMIP6 and a comprehensive multi-model uncertainty analysis around Pinatubo. In contrast, the CMIP6

Model Intercomparison Project on the climatic response to volcanic forcing (VolMIP) focuses on the second part the climatic response to major volcanic forcing in the coupled ocean-atmosphere system. VolMIP defines a common protocol to subject Earth system models and coupled general circulation models to the same volcanic forcing - in terms of aerosol optical properties, based on estimates for major historical volcanic eruptions including Tambora and Pinatubo -, and under a similar range of background climate conditions. By doing so, VolMIP aims at assessing to what extent simulated responses are robust across models and at identifying the causes that limit robust behavior, especially as far as different treatment of physical processes is concerned. This contribution introduces the VolMIP and SSiRCMIP projects, presents ongoing activities and research highlights achieved within both activities, illustrating how these coordinated modeling assessments are contributing to constrain uncertainties in the climate response to stratospheric aerosol forcing, and discuss potential linkages interactions to AerCHemMIP AEROCM, and CCMI.

O.Torres

Improved OMI record of 500 nm aerosol Single Scattering Albedo

Using measurements ground-based measurements of spectral dependence of aerosol absorption, we have developed a scheme to convert the original 388 nm OMI derived values of SSA to 500 nm. The converted satellite-based values agree with AERONET observations within the uncertainties of both retrievals.

K.Tsigaridis

Organic aerosol volatility parameterizations and their impact on atmospheric composition and climate

Despite their importance and ubiquity in the atmosphere, organic aerosols are still very poorly parameterized in global models. This can be explained by two reasons: first, a very large number of unconstrained parameters are involved in accurate parameterizations, and second, a detailed description of semi-volatile organics is computationally very expensive. Even organic aerosol properties that are known to play a major role in the atmosphere, namely volatility and aging, are poorly resolved in global models, if at all. Studies with different models and different parameterizations have not been conclusive on whether the additional complexity improves model simulations, but the added diversity of the different host models used adds an unnecessary degree of variability in the evaluation of results that obscures solid conclusions. Here we will present a thorough study of the most popular organic aerosol parameterizations with regard to volatility in global models, studied within the same host global model, the GISS ModelE2: primary and secondary organic aerosols both being non-volatile, secondary organic aerosols semi-volatile (2-product model), and all organic aerosols semi-volatile (volatility-basis set). We

will also present results on the role aerosol microphysical calculations play on organic aerosol concentrations. The changes in aerosol distribution as a result of the different parameterizations, together with their role on gas-phase chemistry and climate, will be presented. Oral-text

S.Tsyro

Aerosols in the EMEP model: evaluation and experiments using integrated observations

The EMEP/MSC-W model (Simpson et al., 2012) is applied in both for policy related applications and research studies. Model calculated PM10 and PM2.5 levels and chemical composition is used in assessments of the exceedances of EU air quality standards and in estimations of PM health effects. The aerosol components accounted for in the model are sulphate, nitrate, ammonium, elemental carbon, primary and secondary organic aerosols, sea salt and mineral dust. The operational model only calculates aerosol mass in fine and coarse fractions and the aerosol extinction is calculated using specific extinction efficiencies, whereas a newly developed research version EMEP-MAFOR applies a Mie-scattering theory to the modelled size-resolved multi-component aerosol. The model is flexible with respect to grid domain (regional/hemispheric/global), projection and resolution (from 1x1º down to ca. 7x7 km); and it has been run with different emissions and meteorology inputs. The performance of EMEP/MSC-W model has routinely been evaluated with EMEP monitoring and intensive measurements data (Aas, Tsyro et al., 2012). The broader use of remote sensing measurements, facilitated last years by the Aerocom tool, contributes to more profound model evaluation and further improvement. The presentation gives several examples of the use of integrated measurements for better understanding of model results. The results from a series of experiments are shown where several descriptions of nitrate aerosol formation (using thermodynamic equilibrium and kinetic approaches) have been tested. Then, modelled mineral dust have been compared with EMEP measured dust concentrations, as well as with satellites' and AERONET AOD and EARLINET extinction profiles for EMEP intensive periods June 2012 and January 2013. This allowed checking the model's ability to reproduce both background dust and Saharan dust plumes. Finally, the analysis results of the effects of model horizontal and vertical resolutions on its calculation accuracy are presented.

M.Val Martin

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

To accurately represent fire emissions in chemical transport and climate models, knowledge of the fire emission injection height is critical. At present, a wide range of arbitrary procedures and elaborate plume-rise parameterizations based on empirical and physical approaches are used to represent the

vertical distribution of fire emissions. However, they are currently poorly constrained. Within the AeroCom-coordinated multi-model Biomass Burning experiment we have proposed to test a fire smoke injection height parameterization developed from MISR plume height stereoscopic observations to be used in future large-scale biomass burning studies. The parameterization is developed from statistical summaries of multi-year plume-height retrievals, stratified by ecosystem-specific regions. Here, we will present the global MISR plume height dataset, the injection height parameterization we have developed, and outline plans for the modeling experiment.

A.Voulgarakis

Local and remote climate effects of regional pollutant emissions

The radiative forcing of short-lived pollutants such as aerosols and tropospheric ozone is highly inhomogeneous and can therefore affect regional temperature, circulation and precipitation in a much more complicated way than the forcing of well-mixed greenhouse gases. However, such effects have not been examined thoroughly and systematically from a global point of view, to understand regional interactions. Here, results from recent simulations with the HadGEM3 global composition-climate model will be presented in which anthropogenic emissions of sulfur dioxide (SO2) and black carbon have been removed in key regions (East Asia, South Asia, Europe, the US, and the northern mid-latitudes as a whole). The linkages between emissions, concentrations, radiative forcing, temperature and precipitation response will be discussed. A particular emphasis will be placed on non-local effects, i.e. how emissions over a certain region can affect other areas remotely. Finally, we will contrast our results with those from similar experiments pursued using the GISS-E2 and the CESM1 models for US and East Asian SO2 emissions, and will discuss the large differences in the models' behavior.

Z.Wang

Impact of radiative transfer algorithm on aerosol direct radiative forcing in GCM

Large uncertainties remain in the estimation of aerosol direct radiative effect (DRE) and forcing (DRF). In this work, using an aerosol-climate model with two- and four-stream radiation schemes, we show that the radiative transfer algorithms contribute to the uncertainties. Aerosol shortwave DREs and heating rate are underestimated significantly by the two-stream algorithm. For present-day conditions, the four-stream algorithms are found to enhance global annual mean aerosol shortwave DREs by more than 8% (14%) at the top of the atmosphere (TOA), 15% (18%) in the atmosphere, and 12% (15%) at the surface for all-sky (clear-sky) case. Increases in aerosol shortwave heating rates due to the four-stream algorithms are generally more than 10% and may even exceed 100%. Our results also show that the two-stream algorithm underestimates the DRFs due to anthropogenic aerosols. This study indicates that

a multi-stream radiative transfer algorithm is necessary to reduce the uncertainties of aerosol DREs and DRFs estimated by global climate models.

D.Winker

All-sky aerosol direct radiative effect and impact of uncertainties in aerosol properties

We have used the CERES-MODIS-CALIPSO-CloudSat (C3M) product to estimate global and regional all-sky aerosol DRE. C3M contains profiles of SW and LW irradiances computed from instantaneous aerosol and cloud profiles from CALIPSO and CloudSat, and collocated MODIS cloud data, all matched to CERES footprints. Aerosol absorption is estimated using a combination of aerosol type information from CALIOP and the MATCH aerosol transport model. Global mean all-sky SW TOA DRE is found to be about 2/3 of the clear-sky DRE, although substantial regional variations in the ratio of all-sky to clear-sky forcing are seen depending on aerosol type and surface albedo. The impact of uncertainties in AOD and aerosol absorption on the estimates of aerosol DRE have been explored by perturbing the aerosol properties used in the radiative calculations. However, the aerosol DRE is found to be less sensitive to uncertainties in aerosol absorption than in some other recent studies. Details of the approach will be presented, along with a discussion of results.

CALIPSO version3 aerosol climatology

Y.Xue

Inter-comparison of three AATSR L2 AOD products over China" for AeroSat

The Advanced Along-Track Scanning Radiometer (AATSR) aboard on ENVISAT is using to observe the Earth by dual-view. The data of AATSR can be used to retrieve AOD both over land and ocean, which is an important merit in the characterization of aerosol properties. In recent years, it has established some aerosol retrieval algorithms both over land and ocean, taking advantage of feature of dual-view whcih can help eliminate contribution of surface to top of atmosphere (TOA). Aerosol_cci as part of Climate Change Initiative (CCI) provides (table 1) users three algorithms for AATSR, including the Swansea algorithm(SU), the ATSR-2/AATSR dual view aerosol retrieval algorithm (ADV) and the Oxford-RAL Retrieval of Aerosol and Cloud algorithm. The Validation Team of Aerosol-CCI has validated AOD (both level 2 and Level 3 products) and AE (Level 2 product only) against the AERONET data in a round robin evaluation using validation tool of AeroCOM. For the purpose of evaluating the different performances of these three algorithms on calculating AODs over China, we introduce ground-based data from the

CARSNET (the China Aerosol Remote Sensing Network) which is designed for aerosol observation in China. Because China is vast in territory and of great differences in surface, the combination of the AEROENT and the CATRNET data can validate L2 AOD products comprehensively. The validation results show different performances of these products. The SU products seem to have best performance over different site, mainly due to its strict quality control. The ADV algorithm has same precision as the SU algorithm but with slight underestimation over some sites. The ORAC AODs has the largest coverage at the cost of precision, part of which contains large error, but some are “possible outliers”.

H.Yu

Evaluation of Model Simulations of Trans-Atlantic Dust Transport and Deposition with CALIPSO-based Estimates and Ground-based Observations

We recently developed an 8-year (2007-2014) dataset of CALIOP-based estimates of trans-Atlantic dust transport and deposition fluxes (Yu et al., 2015a, 2015b). In recent years, some new ground observations of dust and particulate matters (PM10) have been available over the Greater Caribbean Basin extending from northeastern coast of South America to Miami of Florida (Prospero et al., 2014). In this study we use these satellite and ground observations to evaluate model simulations of size-resolved dust from both the Goddard Chemistry, Aerosol, Radiation, and Transport (GOCART) offline model and the NASA Modern-Era Reanalysis for Research and Applications version 2 (MERRA-2) aerosol reanalysis (i.e., column aerosol loading being constrained by satellite measurements of radiance at the top of atmosphere). The evaluation is performed on daily, seasonal, and interannual time scales.

H.Zhang

The updated effective radiative forcing of major anthropogenic aerosols and their effects on global climate at present and in the future

The effective radiative forcing (ERF), as newly defined in the Intergovernmental Panel on Climate Change’s Fifth Assessment Report (IPCC AR5), of three anthropogenic aerosols (sulfate, black carbon, and organic carbon) and their comprehensive climatic effects were simulated and discussed, using the updated aerosol-climate online model of BCC_AGCM2.0.1_CUACE/Aero. From 1850–2010, the total ERF of these anthropogenic aerosols was -2.49 W m^{-2}, of which the aerosol-radiation interactive ERF (ERFari) and aerosol-cloud interactive ERF (ERFaci) were ~ -0.30 and -2.19 W m^{-2}, respectively. Sulfate was the largest contributor to the total ERF, with an ERF of -2.37 W m^{-2}. The ERF of black carbon and organic carbon were 0.12 and -0.31 W m^{-2}, respectively.

From 1850–2010, anthropogenic aerosols brought about a decrease of ~ 2.53 K and ~ 0.20 mm day^{-1} in global annual mean surface temperature and precipitation, respectively. Surface cooling was most obvious over mid and high latitudes in the northern hemisphere (NH). Precipitation change was most pronounced near the equator, with decreased and increased rainfall to the north and south of the equator, respectively; this might be largely related to the enhanced Hadley Cell in the NH. Relative humidity near surface was increased, especially over land, due to surface cooling induced by anthropogenic aerosols. Cloud cover and water path were increased, especially in or near the source regions of anthropogenic aerosols.
Experiments based on the Representative Concentration Pathway (RCP) 4.5 given in IPCC AR5 shows the dramatic decrease in three anthropogenic aerosols in 2100 will lead to an increase of ~ 2.06 K and 0.16 mm day^{-1} in global annual mean surface temperature and precipitation, respectively, compared with those in 2010.

S.Zhao

Primary Assessment of the Simulated Climatic State Using a Coupled Aerosol-Climate Model BCC_AGCM2.0.1_CAM

Using the coupled model system of the second generation Global Circulation Model of the National Climate Center (BCC_AGCM2.0.1) and Canadian Aerosol Model (CAM), the simulation of five typical aerosols (sulfate, black carbon, organic carbon, soil dust, and sea salt) and possible effects on the modeled climate are discussed in this paper. The results show that in general, the coupled system simulates the five aerosols reasonably well, and there are obvious improvements in sulfate, dust, and sea salt aerosols compared to the original monthly mean aerosol data used in BCC_AGCM2.0.1. The climatic statistics simulated by the coupled system mainly agree well with observational/reanalyzed data, and are a little better than the monthly mean aerosol data in terms of the total cloud amount, land surface temperature, and precipitation rate. The enhanced representation of dust and sea salt improves the simulation of net solar radiation at the top of the atmosphere in the Sahara Desert and mid-latitude ocean in the Southern Hemisphere and also affects the land surface temperature. The cloud feedback above the tropical ocean caused by the change in aerosol scheme not only alters radiation but also markedly influences precipitation.