ABSTRACTS

of presentations during the

21th AeroCom

and the

10th AeroSAT

workshops

October 10 – 14, 2022

in alphabetical order by presenter

ORAL title	(***present*** / *off-line)*
short Oral / POSTER title	(***present*** / *off-line)*

Ahsan, Hamza

An Overview of Results from Emissions-MIP—a Climate and Chemistry Model Intercomparison Project

Anthropogenic emissions of aerosols and precursor compounds are known to significantly affect the energy balance of the Earth-atmosphere system, alter the formation of clouds and precipitation, and have substantial impact on human health and the environment. Global models are an essential tool used to examine the impacts of these emissions. In this study, we examine the sensitivity of model results to the assumed height of SO2 injection, seasonality of SO2 and BC, and the assumed fraction of SO2 that is injected into the grid cell as SO4 in 11 climate and chemistry models, including both chemical transport models and the atmospheric components of Earth system models. The objective is to quantify the influence of these emissions characteristics on model simulations and to better understand the extent to which these characteristics affect results across different models. Each model simulation reported gas and aerosol concentration and deposition rate variables as well as radiative fluxes. Of the perturbations examined in this study, the assumed height of SO2 injection had the largest overall impacts, particularly on net radiative flux (maximum absolute difference of -0.35 W/m2), SO2 lifetime over northern hemisphere land (maximum absolute difference of 0.8 days), surface SO2 concentration (up to 59% drop), and surface sulfate concentration (up to 23% increase). These results imply a need to assure that anthropogenic emissions injection height is accurately and consistently represented in global models.

Allen, Robert

Shortwave Absorption By Methane Mutes its Warming Effects

Although greenhouse gases (GHGs) primarily absorb longwave (LW) radiation, they also absorb shortwave (SW) radiation. Recent studies have highlighted the importance of methane (CH4) SW absorption, which enhances its stratospherically adjusted radiative forcing (SARF) by up to ~20%. The corresponding impacts on the climate system, however, remain largely unquantified. Here, we show that CH4 SW absorption counteracts its global warming, offsetting ~30% of the surface warming and ~60% of the precipitation increase from CH4 LW radiative effects. The CH4 SW-induced cooling is largely due to cloud rapid adjustments, including increased low-level clouds which enhance the reflection of incoming SW radiation, and decreased high-level clouds which enhance outgoing LW radiation. The cloud responses, in turn, are related to the profile of atmospheric solar heating and corresponding changes in temperature and relative humidity. Despite our findings, methane remains a potent contributor to global warming and efforts to reduce CH4 emissions are vital for keeping global warming below 2C above preindustrial values.

Aoki, Kazuma

Variability of the aerosol optical properties by long-term measurements of ground-based and ship-borne

We investigated the long-term monitoring of aerosol optical properties at ground and ship-borne measurements since 1990's by using the Sky radiometer (POM-01, 02: PREDE Co. Ltd., Tokyo, Japan.). Although there are some problems, we were able to continue our observations despite the effects of COVID-19. Our objectives were to understand the effect on earth climate change, and to validate satellite and numerical models. GCOM-C (JAXA) satellite marks the fifth year since its successful launch in December 2017. In this project, we are conducting different research (Atmosphere, Ocean, Cryosphere, Land) to proposals for validation and analysis, focusing on the wavelength dependence of optical properties. These data have revealed various events (anthropogenic and/or natural aerosols), seasonal and long-term trends. We provide the recent observation and re-analysis of solar aureole, in this presentation, on the aerosol optical properties measurements with temporal and spatial variability in the long-term record.

Arola, Antti

Aerosol effects on clouds are concealed by natural cloud heterogeneity and satellite retrieval errors

One major source of uncertainty in the cloud-mediated aerosol forcing arises from the magnitude of the cloud liquid water path (LWP) adjustment to aerosol–cloud interactions, which is poorly constrained by observations. Many of the recent satellite-based studies have observed a decreasing LWP as a function of cloud droplet number concentration (CDNC) as the dominating behavior. Estimating the LWP response to the CDNC changes is a complex task since various confounding factors need to be isolated. However, an important aspect has not been sufficiently considered: the propagation of natural spatial variability and errors in satellite retrievals of cloud optical depth (COD) and cloud effective radius (CER) to estimates of CDNC and LWP. Using satellite and simulated measurements we demonstrate that, because of this propagation, even a positive LWP adjustment is likely to be misinterpreted as negative. This biasing effect therefore leads to an underestimate of the aerosol-cloud-climate cooling and must be properly considered in future studies.

Bian, Huisheng

Investigation of the NASA GEOS aerosol hygroscopicity using multi-campaign multi-sensor NASA aircraft measurements

Aerosols exist in the atmosphere ubiquitously without border and beyond surface. They impact on people's lives in various ways through their roles in atmospheric radiation, cloud formation, nutrient supply, and air quality. All of these impacts depend heavily on an aerosol physical property: aerosol hygroscopic growth factor (HGF). It is challenging to have a good simulation of HGF from a modeling perspective. HGF is adjusted by numerous factors including the ambient condition of relative humidity and the properties of aerosol's type, size, oxidation degree, mixing status, and more. Among these factors, aerosol size distribution (SD) affects HGF and it in turn can also be affected by HGF substantially. We intend to apply NASA aircraft measurements over a long-term course synergistically to enhance the simulation capability of HGF and SD in the NASA GEOS Earth System Model (ESM) and assess their impact on atmospheric radiative field. Toward this goal, we will present the preliminary evaluation of GEOS HGF and SD using multi-campaign multi-sensor aircraft measurements.

Chen, Cheng

Global aerosol absorption constrained by multi-angular polarimetric remote sensing

The quantitative estimation of solar radiation absorbed by atmospheric aerosol are rather uncertain due to the lack of reliable information about the global distribution of aerosol absorption. Yet, the information about global aerosol properties are commonly provided by single-viewing photometric satellite sensors that are of limited sensitivity to aerosol absorption. Here, we demonstrate that remote sensing by satellite multi-angular polarimeters (MAP) provide constraints on emission of absorbing aerosol species that could be further used to estimate global aerosol absorption and its effect on climate. Our resulting estimate of present-day globally-averaged aerosol absorption optical depth (AAOD) at the 550 nm wavelength is 0.0070, with a 95% confidence interval of [0.0068, 0.0073], and 72.9% of this absorption is caused by anthropogenic emissions. These values represent higher absorption associated with anthropogenic activity than previously thought by about a factor of 1.6-1.8. The all sky direct radiative forcing (DRF) due to black carbon (BC) is +0.33 W/m2, which is in line with the AR5 value of +0.4 W/m2; however, our inclusion of MAP constraints narrows the 95% confidence interval from [+0.05, +0.8] to [+0.17, +0.54].

Chimot, Julian

OSSAR-CS3 - Two years of (pre)operational NRT (Near Real Time) Copernicus Sentinel-3 aerosols - Lessons learned and new developments for the next 2 years

EUMETSAT leads the European NRT aerosol products since 2014 from its Member State and Copernicus space-borne sensors, with a 1st key objective to support NRT operational assimilation by air quality, climate and meteorology services. After Metop with PMAP (Polar Multi-sensor Aerosol optical Properties), the Copernicus NRT Sentinel-3 Aerosol is the 2nd European product with this objective. It is derived from the OSSAR-CS3 (Optimized Simultaneous Surface Aerosol Retrieval for Copernicus Sentinel-3) processor. Initiated in August 2020, with the Demonstrational Collection 1, the product maturity has evolved in October 2021 to Preliminary OPErational thanks to its improved Baseline Collection 2. The OSSAR-CS3 algorithm baseline has been jointly developed between EUMETSAT scientific experts & the Swansea University team led by Prof. Dr. Peter North. This presentation will share with the AEROSAT community the overall lessons learned (strength & weaknesses) from the first 2 years of the Copernicus NRT Sentinel-3 Aerosol product and the associated planned developments. These notably cover:

a) The 2-year validation status, including match-up with AERONET, MAN (ACES project), match-up with spatially-temporally collocated MODIS Terra, and regional/global inter-comparison on daily & weekly all VIIRS NOAA (SNPP & NOAA-20) and the latest MISR NRT aerosol products.

b) The new SLSTR algorithms implemented directly into OSSAR-CS3, since Collections 2 and 3 (scheduled for autumn 2022): e.g. the Naïve Probabilistic CLA (Cloud and Aerosol) identification, new glint, snow and ice masks, and the L2 (Level 2) scene homogenization. These have notably lead to a much enhanced representation of low and medium aerosol episodes over ocean, and removal of all warm broken clouds over hot lands (cf. Collection 1 issues). NB: the SLSTR L1 Basic Cloud Mask is not used anymore.

c) The empirical ICA (Information Content Analyses) estimator for the introduction of constraints in the land surface / aerosol decoupling signals.

d) The dual-angular model over Lands in specific cases: e.g. high ICA estimation, and improvements over bare soils (ACES project).

e) The land surface reflectance 1st guess used in the cost function optimizer: the land vegetation spectral model based on the AFRI (Aerosol Free Ratio Index) – used since Collection 1 & 2 with a Red-NIR-SWIR(2.25 um) spectral matching while the 2nd SWIR band (1.6 um) will be added via the new AFRI-SWIR in Collection 3.

EUMETSAT experts will initiate the Baseline 3, with the Collection 3.0 deployment, in Fall 2022, with several developments above have been agreed with the Copernicus Atmospheric Monitoring Service (CAMS), the SLSTR Quality Working Group (QWG) and the S3 Mission Constellation Review. The overall L2 AOD (550 nm) uncertainty over ocean will remain similar but with a much greater spatial coverage, while the AOD (550 nm) over lands will show a noticeable reduction of its bias from ~0.1 to much closer to ~0.05 in the North hemisphere over vegetation and hybrid soils. In order to evolve towards an OPErational scientific maturity, EUMETSAT is preparing the following two evolutions thanks to internal and external partnership:
- Collection 3.1 will obtain the necessary improvement of all water color modeling in the red band using the Sentinel-3 L2 OLCI (Ocean & Land Color Instrument) product led by the EUMETSAT Marine team.
- A revised Day-2 algorithm baseline will include a pre-calculated Land Surface Reflectivity (LSR) product for all land cover, an optimized cost-function scheme, and new retrievals (aerosol layer height and dust) benefiting from parallel aerosol development activities (Sentinel-3 OLCI, EPS-SG, MTG, CO2M).

Chin, Mian

Towards using GEO-LEO satellite observations for air quality research and applications: insights from ground-based AOD and PM2.5 measurements and model simulations

We will discuss the possibilities and challenges of using aerosol observations from low earth orbiting (LEO) and geostationary (GEO) satellites for air quality applications with insights from the ground-based AOD and PM2.5 measurements and model simulations. We will address the following two questions:
1) What are key factors determining the relationship between column aerosol optical depth (AOD) and surface PM2.5 over different spatial and temporal scales, including aerosol vertical distributions, composition/size, and meteorological conditions?
2) What are the most scientifically robust and logistically feasible ways to convert satellite observations of aerosols to surface PM2.5 for air quality applications?

Chin, Mian

Progress and updated results of the AeroCom UTLS+ACAM experiment

We report the progress and updated results of the AeroCom UTLS+ACAM experiments from 8 sets of model output from the participating modeling groups. We will (1) briefly recap the results shown in last AeroCom workshop on UTLS aerosol transport and distributions, (2) present new comparisons with the StratoClim aircraft data over Nepal/India on aerosol composition and vertical distribution, (3) compare the aerosol deposition tracer (Pb-210) among models, and (4) discuss how to wrap it up.

Clifton, Olivia

Quantifying the influence of mechanistic representation and uncertainty in particle dry deposition on air pollution and climate

Dry deposition removes short-lived climate pollutants and their precursors from the atmosphere. The aerosol dry deposition schemes in most global models do not reflect current mechanistic understanding gleaned from observations. Here we demonstrate the impact of a more process-based aerosol dry deposition parameterization on near-surface particulate matter (PM) abundances as well as aerosol direct and cloud albedo effects using the NASA GISS global Earth System Model (ModelE). The old aerosol dry deposition scheme in ModelE is widely used in global modeling, and considers changes in gravitational settling with particle size, but only represents other dry depositional processes through highly parameterized dependencies on turbulence. We investigate the impact of the new dry deposition scheme with two aerosol configurations of ModelE – a "bulk" mass-based scheme and a modal scheme that more explicitly represents internal mixing and microphysics. We find that PM responses vary by region, season, and particle size, as well as by aerosol configuration. Changes to particle dry deposition, which are strongly a function of particle diameter, have a greater influence on the historical cloud albedo effect (up to 0.1 W m-2) when aerosols are more explicitly resolved in the modal scheme. On the other hand, impacts on the direct aerosol effect are small for both model configurations. In general, the low number of aerosol flux measurements and strong variability across existing observations challenge confidence in our understanding of dry depositional processes and changes with environmental conditions. Nonetheless, our work suggests that capturing dry deposition may be important for accurately estimating present-day air pollution, as well as increases in aerosol abundances over the historical period.

Devi, Archana

Global maps of aerosol single scattering albedo using combined CERES-MODIS retrievals

Aerosol absorption is an important parameter for assessing the climatic impact of aerosols. In this study, we present a multi-sensor algorithm to generate global maps of single scattering albedo (SSA) 550 nm using the concept of 'critical optical depth.' Global maps of SSA were generated following this approach using spatially and temporally collocated data from Clouds and the Earth's Radiant Energy System (CERES) and Moderate Resolution Imaging Spectroradiometer (MODIS) sensors on board Terra and Aqua satellites. Limited comparisons against airborne observations over India and surrounding oceans were generally in agreement within ±0.03. Global mean SSA estimated over land and ocean is 0.93 and 0.97, respectively. Seasonal and spatial distribution of SSA over various regions are also presented. Sensitivity analysis to various parameters indicate a mean uncertainty around ±0.044 and shows maximum sensitivity to changes in surface albedo. The global maps of SSA, thus derived with improved accuracy, provide important input to climate models for assessing the climatic impact of aerosols on regional and global scales.

DeLessio, Meagan

Initial results and evaluation of brown carbon representation in GISS ModelE

Brown carbon (BrC) is an absorbing organic aerosol primarily emitted by the combustion of biomass and biofuel. While field and laboratory studies have shown that BrC exhibits light absorption unique from black carbon (BC) and organic carbon (OC) aerosols, the radiative forcing of BrC is still highly uncertain. We present the implementation of BrC in the One-Moment Aerosol (OMA) module of the GISS ModelE ESM. Primary BrC is emitted from biomass burning with a range of optical properties and is processed through a unique chemical aging scheme. Brown secondary organic aerosols (SOA), formed from several biogenic and anthropogenic precursors, are also represented. Several simulations–with varied emissions, optical properties, and chemistry–have been run to assess the sensitivity of this initial BrC implementation within ModelE. Initial results show a peak in BrC concentrations near the tropopause, around 200 mb. As BC aerosols do not reach this height in ModelE, this suggests a new source of absorption in the upper troposphere. Organic aerosol representation can be further evaluated through comparison to AERONET retrieval data of BrC mass and optical depth, and total aerosol optical depth.

Digby, Ruth

Observational constraints on CMIP6 aerosol sensitivity from the COVID-19 lockdowns

The short-term climate response to an abrupt reduction in aerosol emissions, such as might follow the implementation of strict air quality legislation, remains poorly constrained. Predicting these impacts requires that Earth System Models accurately represent both the response of atmospheric aerosol concentrations to a change in emissions, and the impact that this concentration change has on climatic variables such as temperature, precipitation, and cloud properties. Here we present the results of a model evaluation study focused on the first of those two requirements. By comparing the simulated response of aerosol optical depth to COVID-19-like emission reductions with satellite observations from the spring of 2020, we can assess how well climate models represent the impacts of a rapid reduction in aerosol emissions. We evaluate changes in total and dust-subtracted aerosol optical depth in models from the CovidMIP project, which forced CMIP6-class models with a COVID-19-like reduction in aerosols and greenhouse gases. We then perform sensitivity tests with CanESM5 to quantify the influence of confounding factors including natural aerosol emissions, errors in the baseline and perturbed emission inventories, and meteorological variability. Of the four models assessed in detail, three -- CanESM5, MIROC, and MRI -- exhibit aerosol sensitivity consistent with remotely sensed observations, while NorESM2-LM displays lower sensitivity. These results will provide critical context for interpreting the simulated climate impacts of proposed emission mitigation pathways.

Dubovik, Oleg

GRASP (retrieval) overview presentation

Dubovik, Oleg

Aerosol information to come from multi-angular satellite observations: perspectives and practical advancements

Based on the numerous results of theoretical and practical studies Multi-Angular Polarimeter (MAP) is considered as the most appropriate satellite instrument for comprehensive retrieval of properties of aerosols and there is a large number of MAP instruments being launched recently and to be launched in near future. The presentation overviews the achievements, challenges and progress of practical aerosol retrievals from MAP observations and attempts to revise the practical expectations from aerosol remote sensing using MAP observations. The expected scope, the accuracy and desired data formats are discussed for retrievals of diverse aerosol parameters including size distribution, refractive index, absorption, particle non-sphericity, vertical profile, etc. Also, the possibility of identifying the aerosol components of different composition and a possibility of aligning the MAP remote sensing retrieval with aerosol representation in climate models is analyzed. The discussions is mainly based on experiences of obtained with aerosol retrieval using GRASP (Generalized Retrieval of Atmosphere and Surface Properties) approach from real POLDER and HAPR/Cubesat observations and diverse sensitivity tests for evaluating the outcome from future missions such as 3MI/EPS-SG, MAP/CO2M, AOS, etc. In addition, many retrieval aspects were evaluated using the inter-comparisons of GRASP aerosol retrievals from MAP observation with those by SRON RemoTAP algorithm.

Fougnie, Bertrand

Update on PMAp

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Fougnie, Bertrand

Update on OSSAR-CS3

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Ferrare, Richard

Aerosol Humidification Observed by the Airborne High Spectral Resolution Lidar-2

Aerosol backscatter, extinction, and depolarization profiles measured by the airborne NASA Langley Research Center High Spectral Resolution Lidar 2 (HSRL 2) in the vicinity of the Philippines during the NASA CAMP2Ex mission and over the western Atlantic Ocean during the NASA EVS 3 ACTIVATE campaign are used to study the change in aerosol properties with relative humidity (RH). HSRL-2 measured profiles of aerosol extinction and optical thickness via the HSRL technique at 355 and 532 nm and profiles of aerosol backscatter and depolarization at 355, 532, and 1064 nm. Coincident dropsonde and airborne in-situ Diode Laser Hygrometer measurements show that HSRL-2 observations of increased aerosol backscatter and extinction near the top of the mixed layer were usually associated with pronounced (>10-20%) increases in RH. HSRL-2 measurements of aerosol backscatter and extinction and dropsonde measurements of RH are used to compute aerosol humidification enhancement factors [e.g. f(RH)] for aerosols within well mixed boundary layers. Initial results show that the average f(RH) (80%/20%) derived from the HSRL-2 and dropsonde measurements was higher than the average corresponding f(RH) derived from airborne in-situ measurements. This difference is most likely because the aerosol humidification factor derived from the HSRL-2 measurements corresponds to contributions from both fine and coarse mode aerosol, in contrast to the in-situ humidification factor which corresponds to fine mode aerosol. Both missions occurred predominantly over the ocean where coarse mode sea salt often contributed significantly to the HSRL-2 aerosol measurements. The HSRL-2 measurements indicated that somewhat higher f(RH) values were derived for urban aerosols and lower values for biomass burning aerosols. Average aerosol humidification factors associated with GEOS-5 model simulations are shown to be considerably higher than those derived from both HSRL-2 and in situ measurements.

Garrigues, Sebastien

Assimilation of multi-satellite aerosol optical depth (AOD) in the Copernicus Atmospheric Monitoring Service (CAMS) data assimilation system.

Global monitoring and forecasting of aerosols are required to analyze and predict the impacts of aerosols on air quality and their role in modulating the climate variability. To achieve this, the Copernicus Atmosphere Monitoring Service (CAMS, http://www.copernicus-atmosphere.eu) provides reanalysis records and operational 5-day forecasts of aerosols using the Integrated Forecasting System (IFS), which combines state-of-the-art meteorological and atmospheric composition models together with the data assimilation of satellite products. The current CAMS aerosol monitoring and forecasting system relies on the assimilation of Aerosol Optical Depth (AOD) at 550 nm observations derived from MODIS (TERRA and AQUA satellites) and PMAp (synergy between GOME-2, IASI, AVHRR onboard METOP-A,B,C satellites) datasets. Implementing new observational data streams is of great importance in order to exploit more accurate observations, to increase the spatial and temporal coverage of the observations, and to increase the resilience of the data assimilation system to the failure or disruption of instruments.
In this paper, we present the results from the assimilation of the VIIRS EPS AOD product from S-NPP and NOAA-20 satellites produced by NOAA. Several long experiments (June 2020-February 2021) were conducted to test the impact of assimilating the VIIRS AOD product in the IFS and evaluate the benefit compared to the assimilation of MODIS. Results show a decrease of the analysis increments over ocean which were deemed to be too high due to the positive offset of MODIS/TERRA. Over land, the assimilation of VIIRS increases the analysis particularly over biomass burning and dust source regions. The global comparison against AERONET shows that the assimilation of VIIRS reduces the bias in AOD 24h forecast particularly over Europe and desert sites. It also results in an increase of PM2.5 forecast and a reduction of PM2.5 bias over Europe.

Ginoux, Paul

Sensitivity of dust modeling to anthropogenic emission factors using GFDL ESM4

Human activities may affect wind erosion directly by disturbing soil properties or indirectly through the increased desertification associated with climate change. The dynamical land model (LM4) of the GFDL Earth System Model (ESM4) simulates vegetation changes including leaves, fine roots, heartwood, sapwood, seeds, liter, and nonstructural carbon. LM4 describes the land within each grid cell as a collection of tiles of various types, categorized as natural, secondary (previously harvested or used for agriculture), pasture, croplands, rangelands, lake, or glacier. LM4 also includes a fire model that simulate fires daily and includes both multiday and crown fires. Each of these tiles experiences the same forcing from the atmosphere above but responds with its own vegetation, soil properties, and surface fluxes. Dust emission is calculated separately for each tile before being aggregated and passed to lowest layer of the atmosphere where it is transported until its deposition on land or ocean. This numerical treatment of dust allows evaluating its sensitivity to both climate and land use changes. In this presentation, after a short evaluation of ESM4 performances at simulating dust, the results of a sensitivity study of the different dust emission parameters associated with land cover types, including land use, will be analyzed. This analysis will provide some insights of key controlling factors of natural and anthropogenic dust emission.

Gonçalves Ageitos, María

Assessment of modelled dust mineralogy with multiple Earth System Models

Soil dust aerosols have multiple impacts on the Earth System. Among others, they interact with short and long wave radiation, foster the generation of ice clouds, affect atmospheric chemistry and influence biogeochemical cycles. All these processes are sensitive to the mineralogical composition of dust, which can have significant regional variations. Earth System Models (ESMs) increasingly represent this complexity, evolving from the assumption of dust as a homogeneous species towards its characterization as a mixture of multiple components with their own physicochemical properties. Here, we compare the modelled dust mineralogy from different state-of-the-art global models, namely: MONARCH, CESM-CAM6, GFDL-AM4, and IFS-AER, and assess them against a compilation of observed mineral mass fractions. Model-dependent factors, such as the size distribution, significantly affect the modelled minerals' geographical distribution and atmospheric abundances. Our limited knowledge of the composition of the uppermost layer of the parent soils and the resulting size-dependent emitted mineral fractions constitute relevant sources of uncertainty shared by all models. Ongoing remote sensing efforts through the NASA Earth Surface Mineral Dust Source Investigation (EMIT) mission aim to map the mineralogy of dust sources, providing a key input to better characterize dust mineralogy in ESMs and further explore its multiple impacts on climate.

Gryspeerdt, Edward (Povey, Adam)

The impact of cloud and aerosol retrieval biases on forcing constraints.

The effective radiative forcing from aerosol cloud interactions remains uncertain, with a large spread between different models. For some components (such as the RFaci or Twomey effect), the diversity in model estimates is similar to the uncertainty in the observation-based estimates. Improvements in observation-based estimates are required to better constrain models. The observations used to create these constraints have biases which affect the accuracy of the constraints. Different aerosol products, used as proxies for CCN, produce a range of forcing estimates. Droplet number concentration retrievals, a central component of many observation-based forcing estimates, have errors that depend on the background meteorological and cloud state. Here we look at the impact of these retrieval biases on forcing estimates, where different observation-based estimates can be reconciled with models and each other, and how this guides future model intercomparisons focusing on the indirect effect.

Hasekamp, Otto

Constraining aerosol properties using polarimetric satellite observations

Multi-Angle Polarimetric (MAP) measurements provide the largest theoretical information content on aerosol properties from a passive remote sensing point of view, and have the potential to provide accurate retrievals of aerosol optical (AOD, SSA) and microphysical properties (size distribution, complex refractive index, shape). So far, only the PARASOL satellite with onboard the POLDER-3 instrument has provided a multi-year data set of MAP measurements between 2005-2013. After a gap of more than 10 year in satellite-based MAP measurements, the NASA PACE mission (launch early 2024) will continue such observations in improved form having onboard both the SPEXone and HARP-2 polarimeters. From 2025 onwards, more MAP instruments will be launched (3MI, MAP-CO2M, AOS). Here we present the latest developments in MAP aerosol retrievals from PARASOL performed in the framework of the ESA HARPOL project. During HARPOL, the two main MAP retrieval algorithms – RemoTAP from SRON Netherlands Institute for Space Research and GRASP from the University of Lille and the GRASP-SAS company – have been further developed and significantly improved. We present a detailed comparison between aerosol properties (AOD, size, absorption) retrieved by GRASP and SRON/RemoTAP, including a validation against AERONET as well as a comparison of global aerosol retrievals. Finally, we will discuss and demonstrate how aerosol properties retrieved from MAP instruments can be used to constrain aerosol composition/type, and look ahead to the upcoming MAP missions.

Haugvaldstad, Ove

tbd …

Henkes, Alice

The Hemispheric Contrast of the Anthropogenic-Aerosol-Cloud Interaction in the ICON-A-HAM2.3 Model

Using the global atmosphere-aerosol Model ICON-A-HAM2.3, we assess aerosol effects by analyzing the hemispheric contrast. It is investigated by comparing a reference simulation with a sensitivity simulation where the anthropogenic aerosol emissions between the northern and southern hemispheres are flipped and global observational datasets. The results and discussion focus on the impact of flipping emissions between hemispheres on marine stratocumulus clouds, especially over the southern hemisphere.

Herrera, Milagros

A comprehensive analysis of dynamic error estimates provided by GRASP algorithm for satellite observations

The amount of available satellite data and the algorithms to obtain products from them have increased in the last decades. In particular, multi-angular multi-spectral polarimetry (MAP) is proven to be one of the ideal measurements for aerosol and surface characterization from space. Different studies have been carried out from the use of different algorithms for the retrieval of aerosol and surface properties from this information (e.g., Dubovik et al. (2019); Chen et al. (2020)). However, the reliable characterization of the error budget of the retrieval products is a very challenging aspect that currently remains not fully resolved in most remote sensing approaches.
GRASP (Generalized Retrieval of Atmosphere and Surface Properties) has been adapted over the last decade for the operational processing of polarimetric satellite observations and several aerosol products have been generated, e,g., for POLDER/PARASOL observations, which are released and publicly available. Moreover, the GRASP algorithm has the capability to provide the full covariance matrices, i.e. not only variances of the retrieval errors and also correlations coefficients of these errors. Therefore, an important further step is to provide the error estimates for the different satellite products and analyze

the correlation matrix that can help to optimize the observation schemes and retrieval setups.
In this study we describe and analyze the dynamic error estimates provided by GRASP algorithm for retrieved aerosol and surface properties from different satellite observations, for example, POLDER/PARASOL, 3MI, MAP/CO2M. In order to evaluate the error estimates, we conduct a series of comprehensive sensitivity tests, for different aerosol models, when simulated data are perturbed by random and systematic errors and inverted. Using the results of these tests we discuss and analyze the dynamic error estimates of aerosol and surface retrieved properties by GRASP algorithm from satellite observations. Finally, we illustrate the performance of GRASP error estimates in real applications.

Hoesly, Rachel

A global anthropogenic emissions inventory of reactive gases and aerosols (1750 – 2021): an update to the Community Emissions Data System (CEDS)

Global anthropogenic emissions are crucial for understanding atmospheric pollution and its associated impacts on environment and human health. The ability of earth systems models to represent radiative balance, cloud processes, and other phenomenon rely on high quality, recently updated input emissions data. However, many inventories lag by 5 years or more and are not easily reproducible. The Community Emissions Data System (CEDS) was created to fill this void, producing readily updateable historical anthropogenic emissions data sets by combining existing energy data and inventory data, first used in CMIP6. Here we report on an updated global anthropogenic emission inventory (1750 – 2021) of aerosol (BC, OC), aerosol and ozone precursor compounds (SO_2, NO_x, NH_3, CO, NMVOC), carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). We report annual country-total emissions for 71 sectors and 8 fuel categories (3 coal types, 3 oil types, natural gas, and biomass). We also reported monthly gridded (.5 x .5 degree for all years, and .1 x .1 degree for recent years) emission fluxes for each emission species and 8 anthropogenic sectors for use in earth system models. Gridding sectors include agriculture; energy; industry; transportation; residential, commercial, and other sectors (RCO); waste; solvent use; and international shipping. Relative to the previous CEDS release (O'Rourke et al 2020), this update extends emissions from 2019 to 2021; breaks out aluminum, iron and steel, and non-ferrous metal productions; and utilizes point source data from the OMI satellite data and other sources to refine gridded emissions; among other updates. This data set is currently under development and will be released Fall 2022.

Jafariserajehlou, Soheila

The latest updates of Polar Multi-sensor Aerosol product (PMAp)

The Polar Multi-sensor Aerosol product (PMAp) provides aerosol properties (e.g. aerosol optical depth and type) retrieved from Metop series of satellites from the EUMETSAT Polar System (EPS). PMAp is a near real time product (dissemination < 3h after sensing time), which uses the operational infrastructures at EUMETSAT to retrieve the aerosol properties globally over ocean and continents. The retrieval algorithm of PMAp is based on a synergistic approach and uses measurements of the three instruments on-board Metop: GOME-2, AVHRR, and IASI. The synergy of the rich spectral (UV-TIR) content with the measurements with high spatial resolution and un-polarized and polarized reflectance form a hyper-instrument and allows a refined detection of cloud, sub-pixel clouds and aerosol properties [1]. In addition, a computationally efficient colocation algorithm is used in PMAp to enable

the near real time retrieval of this multi-sensor product.
The first version of PMAp was developed and released by EUMETSAT in April 2014. After several updates of the retrieval algorithm, especially the last version released in 2021 for which a significant improvement was observed over land, the new version of PMAp will be released in 2022. The main goal in this version is to change the status of retrieval over land from demonstrational to operational. We present here the main upgrades of this version of PMAp. Among others: updating the degradation correction of GOME-2 PMD Level 1b data for Metop-B and C to account for the aging of the sensor and updating of the radiometric adjustment for both Metop-B and -C. The AOD retrieval over land and ocean is now improved thanks to the mentioned upgrades and the strong cross-track variation of AOD observed previously in Metop-C is now solved. In addition, PMAp-B and –C are more consistent and the difference between the AOD retrieved from the two platforms is minimized. The validation studies of the new PMAp against AERONET and comparison to other satellite AOD products (e.g. MODIS, VIIRS, S3) will be presented as well as analysis related to surface reflectance.

Jia, Hailing

What can we learn about aerosol-cloud interactions from decadal trends?

Anthropogenic aerosols exert a negative effective radiative forcing that offsets part of the green-house gas warming. However, both the weak signal of aerosol-cloud interactions compared to the natural variability of clouds and the satellite retrieval biases of aerosol/cloud properties, make it a challenge to identify and quantify aerosol effects on cloud especially from the observational side. To sidestep the complications raised from these issues, the evident trends in anthropogenic emissions over major industrial region during the past few decades, offers an opportunity to detect and assess confidently the effects on cloud properties and the subsequent radiation budget. By combining multiple satellite observations reanalysis, and CMIP6 ensembles, this study shows the long-term trends (2001-2020) of aerosol, cloud and radiation properties over regions with evident change in anthropogenic emissions, including North America and Europe (strong declines), China (increases and then declines), and India (strong increases), and their adjacent oceans, and further investigates the responses of cloud and radiation properties. It is found that cloud droplet number concentration (Nd) exhibits a good consistency with the trends of aerosol index (AI) over most of regions, with the exception of China and India. In terms of cloud adjustments, however, the trends of cloud fraction (CF) are not always in agreement with the changes in AI and Nd. It is also noted that liquid water path (LWP) shows consistent declines over all regions, indicating a role of varied large-scale meteorological conditions under the background of global warming. Moreover, the clear-sky radiation flux is governed by the trends of AI, while all-sky radiation flux is dominated by the change in CF with only slight influence of LWP.
The results here imply that the emission change significantly affected Nd, providing strong observational evidence of the Twomey effect, while no clear signal of cloud adjustments are detected by decadal trends.

Johnson, Jeffrey

Improving Aerosol Packaging: Interoperable Interfaces between Host Models and Aerosol Packages

As climate models progress towards resolving ever-smaller time and length scales, the need arises to revisit model assumptions and to compare the accuracy and efficacy of different approaches to quantifying relevant physical processes. Aerosols remain one of the most challenging aspects of atmospheric physics, and the need to reexamine and compare is perhaps even more acute in this area than elsewhere. In particular, it would be very instructive to replace one aerosol package with another in a given atmosphere host model and study the resulting changes. However, the traditional structure of aerosol packages in existing climate models makes such focused analysis challenging, if not altogether impractical. We discuss possible ways of surmounting this obstacle in the context of existing aerosol packages and efforts to understand their commonalities and variabilities.

Jordan, George

VolcACI Experiment: A Natural Experiment to Improve Aerosol-Cloud Interactions in Climate Models

Sulphur dioxide and other pollutants form atmospheric aerosols which scatter and absorb sunlight, and influence cloud properties, all of which modulate the Earth-atmosphere energy balance. Aerosol acts as cloud condensation nuclei; an increase in these nuclei leads to a higher number of smaller, more reflective cloud droplets that scatter more sunlight back to space (the 'first indirect effect of aerosols'). This reduction in cloud droplet size decreases the efficiency of collision-coalescence processes which is detrimental to rain initiation. Hence, clouds influenced by aerosols may retain more liquid water extending coverage and lifetime (the 'second indirect effect of aerosols'). Global climate model (GCM) simulations of aerosol-cloud interactions (ACI) have large uncertainties. At its peak, the fissure eruption of Holuhraun (Iceland) in 2014-2015 emitted 120 kilotons of SO2 per day, a rate four times higher than that from all 27 European Union member states and the UK. Oxidation of SO2 via gas- and aqueous-phase reactions resulted in an extensive aerosol plume across the North Atlantic. The near-pristine environment, in which clouds should be most susceptible to aerosol concentrations, coupled with the grand scale of the plume provides an ideal natural experiment for challenging model simulation of ACI. Here we use remote sensing data of the Holuhraun eruption to evaluate the ACI simulations within state-of-the-art GCMs.

Kahn, Ralph

Constraints on Wildfire Smoke Source Strength, Injection Height, and Particle Evolution

Aerosol sources are represented in climate and air quality models with an injection height and a source strength. We have applied a combination of Multi-angle Imaging SpectroRadiometer (MISR) and MODerate resolution Imaging Spectroradiometer (MODIS) observations to help constrain these two key model variables for wildfire smoke plumes. Injection height is obtained from MISR stereo imagery, which makes it possible to map plume elevation and estimate the associated motion vectors at plume altitude near-source, where contrast features in the plume can be identified in the multi-angle views. A current limitation of injection-height mapping is the relatively narrow MISR swath width (~380 km) and 10:30 AM equator crossing time on the day side of Earth. However, upcoming missions, as well as advanced imagers on geostationary platforms, promise to greatly expand the spatial and temporal range over which this technique can be applied. We estimate source strength by matching forward-simulated plume aerosol optical depth (AOD) from models with AOD snapshots retrieved from MODIS observations. This technique works best for large, isolated plumes common in boreal forest, and tends to fail where plume AOD is low and/or background AOD, distinct from the specific source of interest, is high. These two approaches for constraining aerosol modeling with satellite observations have been the subject of ongoing AeroCom/AeroSat studies by our group. A third effort applies the combination of MISR plume heights, wind vectors, and particle microphysical property constraints to infer smoke-plume particle evolution processes and timescales, including the emission and subsequent evolution of black and brown smoke. In this presentation, we will provide an update on the status of these efforts.

Kayetha, Vinay

*UV-VIS Spectral aerosol absorption dataset derived from AERONET-OMI-MODIS synerg*y

Measuring spectral aerosol absorption remains a challenging task in aerosol studies, especially in the UV region, where ground and airborne measurements are sparse. Here, we introduce an aerosol single scattering albedo (SSA, ωo) database in the UV-to-visible wavelength range (340–670 nm) derived from the synergistic combination of collocated ground measurements of spectral aerosol optical depth (AOD) from 110 AERONET (AErosol RObotic NETwork) sites with radiance measurements at 340, 354, and 388 nm from OMI (Ozone Monitoring Instrument) and at 466 and 676 nm from MODIS (MODerate Imaging Spectrometer). The approach consists in explaining satellite-measured near-UV and visible radiances in terms of measured total column extinction AOD and retrieved total column wavelength dependent SSA using radiative transfer calculations. Required information on aerosol particle size distribution is adopted from AERONET-based aerosol type-dependent seasonal climatology specifically developed for this project. We will present the resultant regional and seasonal spectral SSA dataset over different regions. The derived aerosol spectral SSA data set provides a valuable addition to the existing aerosol absorption record from AERONET by extending it to the near-UV region. In addition to improving our understanding of spectral aerosol absorption properties, the combined UV-VIS dataset also offers wavelength-dependent dynamic aerosol absorption models for use in retrieval algorithms by currently operating as well as upcoming missions, such as TEMPO and PACE.

Kim, Dongchul

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

The major source of global dust is well established as most of them are originated from a few major source regions of North Africa, Middle East, and Asia which accounting for more than 80% of global dust emission. Although source-receptor relationship over the source regions and downwind is simple and clear, it is difficult to attribute the source contribution when they are mixed during the inter-continental long-range transport. The present study will report the source-receptor relationships over land where affected by both local and transported dust; and remote- and ocean-regions where only contributed by long-range transport, including Arctic, Antarctic, Tibetan Plateau, Mid-Pacific, Mid-Atlantic, and Upper Troposphere. A series of runs with 9 tagged regions were made to estimate the contribution of East- and West-Africa, Central- and East-Asia, North America, and the Southern Hemisphere, including 3 prominent dust hot spots of the Bodele, Middle East, and Taklimakan Deserts. In this work, we quantitively estimate (1) the contribution of dust from different source regions to various land and ocean receptor regions, (2) assess the change of simulated dust size distribution between source and receptor regions. In the update, we will present a preliminary results from the 7 participating models and their mean. Our result shows that dust-belt is the major source of global dust distribution, however models exert large diversity in source contribution over source and remote regions and in seasonality. Vertical distribution of dust source contributions will be compared.

Kim, Dongchul

Multi-model comparison of dust optical depth at 10 um over the Northern Atlantic Ocean

In contrast to the fact that most of ground and satellite-borne remote sensing observation provide aerosol optical depth as 550 nm wavelength (DOD550), the dust aerosol optical depth at 10 um (DOD10) products are also available from the Infrared Atmospheric Sounding Interferometer (IASI) and CALIPSO. Whereas DOD at 550 nm is most sensitive to the fine particles (<2 um), significant amount of dust is in the coarser size and thus more sensitive to DOD10. In addition, although modeled dust optical depth at mid-visible (550 nm) is well established, that of the thermal infrared (10 um) wavelengths in models is not well studied. For the present study, we have requested DOD10 from several models as a part of the AEROCOM-III experiment to examine the current state of dust optical depth at 10 um. In this update, DOD10 from the two IASI observations, two CALIPSO retrievals, six AEROCOM models, and DustCOMM analysis are compared. Our preliminary result shows that the difference in DOD10 between satellites and models is significantly large over the Northern Atlantic Ocean in summer, even where dust signal is most strong and clear.

Kinne, Stefan

The MACv3 aerosol climatology

An updated version 3 of the Max-Planck Aerosol Climatology (MAC) is introduced. This climatology with a gridded (1°x1° longitude/latitude) monthly resolution associates aerosol optical properties - in a 'top-down' approach - uniquely with a mixture of pre-defined aerosol components. The component associated spectral properties, when recombined according to the determined mixtures, define all spectrally varying aerosol single scattering properties needed for the aerosol characterization in broadband radiative transfer.

Kinne, Stefan

The MACv3 associated aerosol radiative effects

In radiative transfer applications MAC v3 (see poster) associated aerosol radiative effects were determined. For all current aerosol, the global impact at the Top Of Atmosphere (TOA) is estimated at -1.36W/m2, with -0.17, -0.69, -0.51, -0.55 and +0.56 W/m2 contributed by mineral dust, seasalt, sulfate, organic matter and soot components. For anthropogenic aerosol the global TOA direct effect is estimated at -0.25W/m2 with -0.05, -0.25, -0.27 and +0.32W/m2 by mineral dust, sulfate, organic matter and soot components. Anthropogenic aerosol cooling is raised to -0.91W/m2 mainly by the first (-0.67 W/m2) indirect effect (more and smaller cloud droplets). Secondary water cloud lifetime effects modulate first indirect impacts with stronger cooling at TOA (via delayed precipitation) in regions of high water cloud cover and by weaker cooling at TOA(via dry air mixing) in regions of low water cloud cover. The assumed compensation of secondary effects (0.0 W/m2), however, is highly uncertain.

Kok, Jasper

Radiative forcing due to historical increase in desert dust

Mineral dust aerosols impact Earth's energy budget through interactions with radiation, clouds, atmospheric chemistry, the cryosphere, and biogeochemistry. As such, past changes in mineral dust could have exerted a substantial radiative forcing of the climate system. We use dozens of records of dust deposition to reconstruct historical changes in dust and find that global dust mass loading is 56 ± 29% (90% confidence interval) higher in the modern climate than it was in pre-industrial times. We combine this finding with estimates of the radiative effects of the various mechanisms through which dust impacts climate, finding that the historical increase in dust produced a global mean effective radiative forcing of -0.07 ± 0.18 Wm-2. Current climate models and climate assessments do not represent the historical increase in dust and thus omit the resulting radiative forcing, biasing climate change projections and assessments of climate sensitivity.

Kolmonen, Pekka

Investigating the performance of a dual-view aerosol retrieval method using machine learning

It has been observed and documented that the acquisition geometry has an effect on the performance of aerosol retrieval algorithms exploiting the dual-view feature of the ESA SLSTR instruments onboard the Sentinel-3 platforms. The decreasing performance has been observed in the Northern Hemisphere (NH) and has been connected to the retrieval geometry in previous studies. The scattering-reflection conditions in NH due to the geometry lead to small top-of-atmosphere (TOA) aerosol signal while the surface reflectance signal is enhanced for most surface types. This simple explanation does not, however, fully cover the performance degradation because the main part of the NH results are of relatively good quality in AERONET validation. In the presented work, we have applied a neural-network based machine learning procedure to the aerosol retrieval results from the SDV (SLSTR Dual View) algorithm. The purpose of the work is twofold. First, to assess the suitability of a neural-network procedure to reliably correct the SDV results. Second, to study the sensitivity of the correction to the various inputs from the SDV output to the neural-network algorithm. The latter purpose is at this point of more interest since it could give some insights for modifying the retrieval algorithm to overcome the geometry-based performance issues. The investigation of the machine-learning results is done with the SHAP (Shapley values) analysis. The dual-view aspect of the aerosol retrieval, the neural-network algorithm and analysis, and the results of the study will be presented.

Kwakye, Samuel

Analysis of insect concentrations using weather radars: Weather radar echoes classification

During the past decades, insect biodiversity and abundance are decreasing. Systematically assessing the decline requires an unintrusive observation of flying insects in the atmosphere, which is also termed "aerosphere". Radar has been known to provide quantitative estimates of flying insects. A weather radar is designed to observe meteorological targets, thus the derivation of insect echoes needs special techniques. The automation of insect retrieval methods from weather radars (artificial intelligence) approaches is well suited. In this study, radar echoes from Level-II(Base) Data and the Hydrometeor classification of the NEXRAD Level-III products from Next Generation Weather Radar (NEXRAD) are distinguished and classified from a machine learning approach at Morris, Illinois, and Ames, Iowa. Weekly aphid counts from suction traps are used as validation data. The variability and distribution of the insect echoes are assessed. Low variability of differential reflectivity is found for precipitation scatterers and centered around zero at Ames but peaks were negative at Morris. The differential reflectivity distributions caused by insects are broad with higher medians At Ames. The reflectivity distribution of the scatterers was distinctive. Decision tree, random forest, and support vector machine models were generated to distinguish 10 combinations of scatterers. Decision trees had the best accuracy to distinguish all the scatterers at Morris and Ames. Across the three algorithms at both sites, moderate insects' concentration and plankton are distinguished best from the support vector machine.

Lee, Huikyo

Evaluating spatial structures of aerosols simulated by the AeroCom models

Topology is the study of shapes. Topological data analysis (TDA) is emerging machinery at the interface of algebraic topology, machine learning (ML), and statistics. TDA has shown a high utility in a diverse range of applications, from social studies, to digital health care, to power systems. While geometrical methods, such as TDA, continue to gain popularity in statistical sciences and ML, from causal inference to deep learning on manifolds, the utility of geometric methods for assessing the spatial characteristics of Earth science datasets is yet untapped. Topological information on the inherent data shape can provide invaluable insights into the latent data structure and organization, and can serve a leading role in understanding spatiotemporal dynamic patterns of observations and climate models.
We developed a novel software toolkit for evaluating AeroCom models against NASA's satellite observations. We will introduce the concept of multi-resolution investigation and apply topological data analysis (TDA) to evaluation of climate models. In particular, we will focus on assessing the AOD from the Phase III control experiment using satellite observations from the Multi-angle Imaging SpectroRadiometer and the MODerate resolution Imaging Spectroradiometer. The main objective is to build a robust and reliable methodology that compares spatial patterns in AOD from different sources and detect anomalous spatial patterns. Our findings suggest that TDA enables us to quantify some higher-order spatial structures in AOD which are inaccessible with the conventional metrics. Consequently, this opens a wider prospect for the application of topological approaches in Earth sciences as demonstrating the added value of high-resolution observations and simulations using the criterion of topological information loss and developing TDA-based toolkits for evaluation of AeroCom simulations against observations at various spatial resolutions.

Lipponen, Antti

NOvel cOmputational methoDs for reLiablE SAteLlite-based Air quality Data (NOODLESALAD)

Poor air quality is one of the most serious environmental health risks of our time. The only way to get global spatially resolved air quality data is to utilize satellite retrievals. NOvel cOmputational methoDs for reLiablE SAteLlite-based Air quality Data (NOODLESALAD) is a project in which we develop new computational methods for air quality (PM2.5) retrievals. In the new PM2.5 retrieval, we will utilize the post-process correction approach, an innovative fusion of satellite data, simulation model information, ground based observations, traditional satellite retrieval techniques and machine learning to produce satellite based PM2.5 particulate matter data with unprecedented accuracy and high resolution. We will apply our new methods to Sentinel-3 Synergy data. In this presentation, I will further explain the technical details of the approaches used in the development of new air quality satellite retrieval algorithm.

Litvinov, Pavel

Synergetic retrieval with GRASP algorithm for enhancement of aerosol and surface characterization

Big variety of different satellites on Earth orbit are dedicated to aerosol studies. However, due to limited information content, the main aerosol products of the most of satellite missions is AOD while the accuracy of aerosol size and type retrieval from space-borne remote sensing still requires essential improvement. Strictly speaking, since the end of the POLDER/PARASOL polarimetric mission in 2013, no single currently operating satellite satisfies the requirements for advanced aerosol characterization. At the same time, the combination of measurements from different instruments can provide better constraints for both aerosol and surface retrieval. The treatment of these multi-instrument data is beyond the capacity for most of the existent traditional algorithms since it requires simultaneous multi-pixel retrieval. For these purposes the new generation of the retrieval algorithm like GRASP can be used. In this presentation we describe possibility of aerosol extended characterization with GRASP algorithm in the post PARASOL period (using GRASP/TROPOMI as an example) as well as the results of GRASP application to the combination of different remote sensing instruments.

Lohmann, Ulrike

Ice clouds: what can we learn satellite retrievals and how do they respond to aerosol perturbations?

The ice phase in clouds is important for precipitation formation and the radiation balance. Pure ice clouds (cirrus) have a positive cloud radiative effect as long as they are not too optically thick. For mixed-phase clouds, which consist of liquid water and ice, the net radiative effect depends on the ratio of liquid water to ice. Thus, for both cloud types, knowledge about the ice crystal number concentration is key to understand their optical properties. However, large uncertainties about the ice phase remain due to limitations in satellite observations of ice cloud properties and insufficient knowledge about these processes from in-situ observations.

Lopatin, Anton

Advanced Synergy Aerosol Product from MERIS and AATSR missions using GRASP

This study outlines the activities performed in the framework of the “CAWA-2 - Advanced Synergy Aerosol Product from MERIS and AATSR” project. It aims at validation of the developed products and understanding of the error budget of the MERIS, AATSR and synergy MERIS+AATSR retrievals obtained by GRASP algorithm. The thorough validation of retrievals over ground-based AERONET sites for the full longevity of the mission as well as the inter-comparison of the new products with the established aerosol products (NASA MODIS, GRASP POLDER and AATSR Swansea) not only over AERONET sites but also over remote areas on the global scale are presented and discussed.

Luffarelli, Marta

Aerosol retrieval in presence of clouds

Aerosol and cloud retrievals from satellite observations are strongly coupled: on one hand, aerosols affect cloud formation and macro physical properties; on the other hand, cloud contamination or broken cloud fields can introduce artefacts in aerosol measurements from space. For this reason, aerosol retrieval is usually performed in clear-sky conditions, where the cloud mask is chosen to be conservative and includes a safety area of few kilometers. The safety area strongly reduces the spatial coverage of aerosol products, with a large percentage of "lost" pixels (up to 20%), i.e., pixels discarded by both cloud and aerosol algorithms. Moreover, it includes the transition zone between pure aerosol and pure cloud particles, where most interactions between aerosols and clouds occur. Even after such a conservative cloud masking, it appears that the retrieved AOT tends to be higher in the vicinity of clouds. This talk will present an overview of the problem and proposed solutions to improve aerosol retrieval from satellites, analyzing the state of the art and recent innovative approaches. In the framework of the aerosol-cci+ project, the CISAR algorithm has been applied to Sentinel-3/SLSTR observations to retrieve both aerosol and cloud optical properties within the same pixel, without applying any external cloud mask. This innovative approach allows continuity between aerosols and clouds, removing the presence of lost pixels while extending the aerosol retrieval in the vicinity and within thin clouds. The impact of these new results on aerosol retrieval from space will be discussed.

Mallet, Marc

Climate models generally underrepresent the warming by Central Africa biomass-burning aerosols over the Southeast Atlantic.

The radiative budget, cloud properties, and precipitation over tropical Africa are influenced by solar absorption by biomass-burning aerosols (BBA). Recent field campaigns, reinforced by new remote-sensing and aerosol climatology datasets, have highlighted the absorbing nature of the BBA over the South-East Atlantic (SEA), indicating that the absorption could be stronger than previously thought. We show that most of the latest generation of general circulation models (GCMs) from CMIP6 underestimates the absorption of BBA over the SEA and do not fully capture the positive (warming) direct radiative forcing at the TOA observed over this region. In addition, underestimating the magnitude of the BBA-induced solar heating could lead to misrepresentations of the low-level cloud responses and fast precipitation feedbacks that are induced by BBA in tropical regions.

Mei, Linlu

Introduction to issues with cloud masking

Miinalainen, Tuuli

Analyzing the climate and air quality effects of aerosol mitigation in India using ECHAM-HAMMOZ combined with statistical downscaling

we utilized a global atmospheric model for analyzing aerosol emission mitigation effects on both global and regional radiative forcing values, and on local air quality. We simulated the fine particulate matter (PM2.5) concentrations with an aerosol-climate model ECHAM-HAMMOZ, and trained a machine learning model to downscale the PM2.5 concentrations modelled for an Indian mega city, New Delhi. Our results suggest that along air quality improvements, aerosol mitigation has potential to decrease radiative heating due to anthropogenic activities in India.

Myhre, Cathrine

The Aerosol, Clouds and Trace Gases Research Infrastructure - ACTRIS

ACTRIS is a European distributed research infrastructure (RI) producing high-quality data for the understanding of short-lived atmospheric constituents and their trends, impacts on health and climate, and interactions. ACTRIS offers data from state-of-the-art observational platforms distributed across Europe, and is linked to global networks. These platforms produce long-term time series based on stringent operational standards. There are around 70 ACTRIS observatories, measuring ground-based aerosol properties and trace gas concentrations, as well as aerosol and cloud profile variables, in total about 100 variables, where not all sites are measuring all. All ACTRIS data are managed and made available to the user communities through the ACTRIS Data Centre (DC). ACTRIS DC is operational, but will undergo major improvement the next years. A new project, ACTRIS-Norway, addresses the new developments, which includes improvement, development, renewal, and new functionalities of the DC infrastructure. Specifically, ACTRIS-Norway will upgrade both the EBAS database infrastructure and the ACTRIS data portal improving the tools and services required for science and policy-oriented data use. Improvements, and a number of new services, will be designed to support climate model community and international programmes addressing atmospheric composition, such as the Convention on Long-Range. Transported Air Pollutants and its European Monitoring and Evaluation Programme (EMEP), the WMO Global Atmosphere Watch.

Pan, Xiaohua

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

The environmental impacts of smoke aerosols depend not only on the emitted mass, but also on the injection height, which affects the longevity, chemical conversion, and fate of the plume's chemical constituents. This is especially true for large boreal forest fires that often inject smoke above planetary boundary layer (PBL) into the free troposphere and even the lower stratosphere. However, most atmospheric chemistry transport models (CTMs) assume that fire emissions are dispersed only within PBL, or use simple vertical profiles or simple plume-rise parameterizations. In order to test the sensitivity of model results to smoke injection height, we proposed the biomass burning emission injection height experiment (BBEIH) in the AeroCom 2019 workshop. The description of implementation methods and input data for BBEIH can be found in https://wiki.met.no/aerocom/phase3-experiments#biomass_burning_emission_injection_height_experiment_bbeih. In BBEIH, we introduced the biomass burning injection heights based on MISR stereo-derived plume-height retrievals (Val Martin et al., 2010; 2018) in four participating CTMs. Specifically, we proposed 4 simulations for the year 2008: 1) BASE: using the biomass burning emissions from Global Fire Emissions Database version 4 with small fires (GFED4s) and the model default fire emission injection height; 2) BBIH: Same as BASE, but using the injection height derived from the seasonally and regionally varying MISR-retrieved plume heights; 3) NOBB: no fire emission; 4) Same as BASE, but using Fire Energetics and Emissions Research version 1.0 (FEER 1.0). We will address the following scientific questions: 1) To what extent are the model simulations sensitive to the assumed biomass burning injection height? 2) In which regions/seasons/surface-types are the aforementioned sensitivities most important? We will update the multi-model inter-comparison with a focus on the vertical aerosol distribution in near-source characteristics and downwind plume evolution.

Pan, Xiaohua

The NASA MERRA-2 Reanalysis Products: Data and Tools Used for Aerosol and Air Quality Studies

The NASA Modern-Era Retrospective analysis for Research and Applications Version 2 (MERRA-2) is atmospheric reanalysis data spanning 1980 to present. It has been produced by the NASA Global Modeling and Assimilation Office (GMAO) and is distributed by the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC). MERRA-2 data includes 100 collections of Earth system variables, mainly from the atmospheric model, such as aerosol fields and meteorological fields, radiation fields, and aerosol fields, guided by the assimilation of as many as six million observations every six hours. MERRA-2 has been one of the most popular datasets from NASA and is widely used in interdisciplinary research and applications, with increasing numbers of new users. For example, at least 7000 users accessed MERRA-2 data at GES DISC in the year 2021, ~1000 more users than in the year 2020. In this presentation, we will introduce the MERRA-2 datasets associated with aerosol and air quality studies and use a wildfire case study to demonstrate the data tools developed at GES DISC to analyze and visualize MERRA-2 data, such as Giovanni and the level 3 and level 4 subsetter, and Jupyter Python notebook. We will also update the status of cloud migration of the MERRA-2 data to Amazon Web Services (AWS).

Pearson, Kevin

New products of global atmospheric aerosol for Sentinel-3 and continuity with ERS-2 and ENVISAT

We present new products of global atmospheric aerosol from Copernicus and ESA satellite missions intended to provide climate-quality, long-term datasets using the ATSR/SLSTR family of instruments. The parameters retrieved include aerosol optical depth (AOD), fine mode fraction, dust AOD, Angstrom exponent and AOD retrieval uncertainty. The method for global aerosol retrieval using SLSTR is based on algorithms developed under the ESA Aerosol Climate Change Initiative (CCI), to develop and evaluate the retrieval of aerosol properties and their uncertainties. Improvements to the products derived from ATSR-2 and AATSR have been developed under the same program. This study has led to the generation of a 17-year dataset for global aerosol retrievals from ERS-2 and ENVISAT (1995-2012), and continued in the Copernicus Sentinel-3 series (2016-present). The datasets are evaluated using the global AERONET sun photometer network. Validation shows a high correlation (R=0.8-0.9) of optical depth when compared to global AERONET measurements and low bias. A version of the (A)ATSR record has been accepted under the Observations for Model Intercomparison Project (OBS4MIPS) to provide datasets suitable for climate model intercomparisons. Daily and monthly gridded data from all the instruments is provided to the Copernicus Climate Change Service (C3S) at 1°x1° resolution. Recent improvements in the long-term archive, and results of testing new products from Sentinel-3 will be demonstrated; notably improved retrievals over bright desert surfaces, and establishing continuity between the instrument records. The dataset is intended for use in climate modelling and benchmarking, and recent results in model and satellite intercomparisons, and estimation of global aerosol radiative effects will be presented. A second product that makes synergistic use of the two sensors, OLCI and SLSTR will be introduced, which provides the potential for greater coverage and retrieval stability.

Popp, Thomas

The CCI simple 4-components approach, its strengths and limitations, different thoughts for improvement

Povey, Adam

The statistical distribution of aerosol optical depth

Aerosol optical depth (AOD) is measured by a myriad of instruments and algorithms because it is known to vary over scales of dozens of kilometres and hours while being an important component of the Earth's energy budget. AOD data are often analysed after aggregation to a regular spatiotemporal grid. This presentation examines the underlying statistics of that aggregation over time and wavelength, identifying circumstances where normal or log-normal statistics and the typical wavelength extrapolation are limited.

Prime, Noah

Introducing Point Source Time Series Data into the Community Emissions Data System

The Community Emissions Data System (CEDS) is a data-driven, open-source project, that produces annual gridded estimates of anthropogenic emissions. CEDS relies on spatial proxy to distribute annual inventories over a global grid. While the CEDS annual inventory estimates are constantly improving, the spatial distribution of emissions has long used the same hands-off approach, though uncertainty in spatial location plays a large role in gridded emission estimates. This has led to an update in the gridding process intended to improve the spatial distribution of emissions by controlling the location of large point source emitters directly. Individual point sources can make up a large proportion of emissions on their own, and collectively be responsible for the bulk of emissions in a given country and sector. The inclusion of additional time series data specific to a point source means more accurate emissions estimates. CEDS has so far introduced time series data for SO_2 emissions processed from NASA’s Ozone Monitoring Instrument (OMI), as well as manually constructed time series for two major smelter complexes in Sudbury Canada, and Norilsk Russia. We see significant changes in the gridded output using this new process and demonstrate the framework that will allow for relatively easy improvements to be made to the CEDS gridded estimates, via the introduction of more point source specific data, as it becomes available.

Robbins, Daniel

Improving Satellite Aerosol Retrievals During Extreme Fire Events in Australia

The bushfire season of 2019/2020 in Australia led to large areas of land being burnt and released significant amounts of material into the atmosphere. These events are set to become more frequent with climate change and pose a significant hazard to people and the environment. Therefore, understanding these events and being able to monitor them using satellites is important for dealing with these events in the future. However, the biomass plumes from these events had aerosol optical depths (AODs) > 5 and generally caused satellite retrievals to be less accurate or fail altogether. Therefore, developing techniques to retrieve aerosol properties for biomass plumes with high optical depth are becoming increasingly important. In this study, we present an improved retrieval scheme for the Advanced Himawari Imager (AHI) using a machine learning and optimal estimation approach to retrieve the properties of these biomass plumes. Sensitivity to the assumed optical properties of the biomass plumes using the Optimal Retrieval of Aerosol and Cloud (ORAC) algorithm is investigated and retrieved AOD values are compared with AERONET data, as well as MODIS DT, MODIS MAIAC and JAXA's aerosol property retrieval product (ARP) for AHI. Height retrievals of the biomass plumes are also compared with CALIOP data for the 2019/2020 bushfire season.

Rosenfield, Daniel

Underappreciated Contrasting Large Effects of Fine aerosols and Coarse salt Aerosols on Clouds

The objective of this presentation is to demonstrate that incorporating both fine aerosols and coarse marine aerosols in weather prediction and climate models is essential to avoid large inaccuracies in their predictions. Two recent studies separated the effects fine and coarse marine aerosols on both shallow and deep cloud. When separated, the fine and coarse aerosols show contrasting large effects on the microstructure, vigor and precipitation of the clouds. The contrasting effects offset much of the net effects when pooled together. However, their realizations are often separated in time and space, and this drives large variability in cloud properties, precipitation, latent heating and radiation. The abstracts of the studies are:
Shallow clouds - Fine aerosols, by acting as cloud condensation nuclei (CCN), suppress rainfall and enhance the albedo and coverage of marine warm clouds, thereby partly counteracting the greenhouse-induced warming. While this is relatively well documented, the co-existing opposite effects of giant CCN from coarse sea spray aerosols (CSA) are poorly quantified. Here, satellite measurements show that the effects of CSA have comparable magnitudes with opposite sign to those of fine aerosols. For fixed cloud liquid water path (LWP) and CSA, increasing fine aerosols decreased rainfall flux and cloud drop effective radius (re) by a factor of 1/4 and 40%, respectively. Conversely, for fixed fine aerosols and LWP, added CSA enhanced rainfall flux and re by a factor of 4 and 35%, respectively. These large and contrasting effects are independent on meteorological conditions. These processes must be fully incorporated into climate models to faithfully represent aerosol effects on clouds, precipitation, and radiative forcing (Fan et al., 2022).

Deep clouds - The known effects of thermodynamics and aerosols can well explain the thunderstorm activity over land, but fail over oceans. Here, tracking the full lifecycle of tropical deep convective cloud clusters shows that adding fine aerosols significantly increases the lightning density for a given rainfall amount over both ocean and land. In contrast, adding coarse sea salt (dry radius > 1 µm), known as sea spray, weakens the cloud vigor and lightning by producing fewer but larger cloud drops, which accelerate warm rain at the expense of mixed phase precipitation. Adding coarse sea spray can reduce the lightning by 90% regardless of fine aerosol loading. These findings reconcile long outstanding questions about the differences between continental and marine thunderstorms, and help to understand lightning and underlying aerosol-cloud-precipitation interaction mechanisms and their climatic effects.

Samset, Bjorn

A strong potential role of aerosol absorption in historical precipitation change

Precipitation change is a key part of anthropogenic climate influence, but one that has been notoriously hard to simulate consistently between global climate models. Similarly, aerosol induced shortwave absorption over the historical era is poorly constrained in both observations and modelling. However, these factors are closely linked, since absorption induced heating of the atmospheric column inhibits precipitation formation. Here I show that the spread in simulated aerosol absorption in the most recent generation of climate models (CMIP6) can be a dominating factor in their uncertainty in global precipitation change over the historical era. In South and East Asia, regions currently strongly influenced by aerosol absorption, CMIP6 indicates a precipitation inhibition of up to 25% of the total, annual mean, with an inter-model spread of similar magnitude. Consequently, until marked improvements are made in scientific understanding of the key absorbing aerosol types; black carbon, organic carbon and dust; projections of regional precipitation change under future anthropogenic emissions will have a major, irreducible uncertainty. In this context, black carbon, which has recently been found to have only a weak influence on global surface temperature, gains added prominence as a contributor to regional precipitation change and its historical and future evolution.

Sawyer, Virginia

20 years of Aqua and AeroCom: regional aerosol trends and time series for MODIS and VIIRS

Aerosol optical depth (AOD) retrieved using the NASA Dark Target algorithm (DT) is available for MODIS Terra beginning in 2000, for MODIS Aqua beginning in 2002, for VIIRS SNPP beginning in 2012, and soon for VIIRS NOAA-20 and multiple geostationary imagers. Although we need at least 30 years of continuity between MODIS and VIIRS versions to construct a climate data record long enough to detect global AOD trends, regional AOD trends are already emerging in the 22-year MODIS record. Terra and Aqua show good agreement for the 20 years that both have been in orbit, and both MODIS instruments show good agreement with SNPP VIIRS for the ten years with all three satellites. Most regional changes appear to result from economic and policy changes dating to different points in the 20-year period: AOD has decreased by between 0.003 and 0.01 per year over eastern China, the eastern United States, much of Europe, and parts of Brazil, while increasing by roughly the same amount over India. However, a coherent regional trend does not imply constant change over time or that current trends can be expected to continue. We investigate regional time series and trends in particle size parameters to further understand changes in AOD during the VIIRS and MODIS missions.

Sayer, Andrew

Assessing the detectability and sensitivity of aerosol retrievals from multi-angle polarimetric measurements to cirrus cloud contamination (cancelled)

Remote sensing of aerosol properties from space is important for air quality, climate, and hazard monitoring applications (among others). In the next decade a plethora of new, advanced sensors will become operational, including several high accuracy multiangle imaging polarimeters (MAPs). The increased information content in MAP measurements will drive significant improvements in space-based aerosol remote sensing. Passive instruments must generally screen out observations affected by clouds prior to performing an aerosol retrieval algorithm. Errors of omission or commission can significantly affect the derived data products. In particular, optically thin ice clouds such as some cirrus can be difficult to detect with these instruments. As these clouds are common it is worthwhile to examine what level of cirrus contamination should be detectable with these future MAPs, and what the consequences on retrieved aerosol properties are in the event that cirrus-contaminated scenes are present but not flagged by cloud screening algorithms. In this work, we assess these factors using forward-modeled synthetic observations based on the realistic GEOS-5 Nature Run (G5NR) in combination with the VLIDORT radiative transfer code. The resulting synthetic observations are input into the Generalized Retrieval of Aerosol and Surface Properties (GRASP) algorithm and inversion accuracy is assessed through comparisons against the G5NR ground truth. We present results for MAP configurations corresponding to desired characteristics of e.g. NASA's upcoming Atmosphere Observing System (AOS) mission.

Schepanski, Kerstin

Impact of environmental changes on dust emission: towards a time-varying modeling approach

Knowledge on the life-cycle of atmospheric dust is crucial for understanding various aerosol impacts, such as effects on the atmospheric radiation budget and on cloud and precipitation formation processes, ultimately altering the Earth's overall energy budget. Although progress was made on characterizing dust sources and mobilization processes in the past, dust models still have large uncertainties regarding the representation of the atmospheric dust life cycle, in particular near sources, based on model diversity and comparison with observations.
The entrainment of mineral dust particles into the atmosphere is determined by a set of atmospheric conditions and soil surface characteristics. Thereby, a change in one of the preconditions may consequently lead to a change in local dust emission flux and thus the atmospheric dust concentration. In the light of rapid environmental changes such as droughts, flooding events or wildfires, the soils' local susceptibility to wind erosion may change in response. Here, we will present an approach to explicitly account for the impact of rapid environmental changes on local dust emission in aerosol-atmosphere models.

Schulz, Michael

20 years of AeroCom

…

Schuster, Greg

Models, In-situ, and Remote sensing of Aerosols (MIRA)

The Models, In situ, and Remote sensing of Aerosols (MIRA) working group connects members of the different aerosol communities through collaborative projects. This abstract, additional details, and a list of current projects can be found at https://science.larc.nasa.gov/mira- wg/. Join our email distribution list of 200+ members at https://espo.nasa.gov/lists/listinfo/mira. In this talk, we will describe MIRA and some current MIRA projects that are relevant to AeroCom (e.g., the Table of Aerosol Optics, or TAO) and the benefits of presenting your multi-disciplinary work at MIRA sessions and meetings.
What is MIRA? MIRA is forum that fosters international collaborations amongst the aerosol Modeling, In situ, and Remote sensing specialties. MIRA advances scientific knowledge about aerosol properties and improves our understanding of air quality, weather, and climate through the pursuit of specific goals. MIRA emphasizes areas of study where the aerosol specialties overlap, and MIRA projects seek additional data and insight from others (observational and modeled).
Why MIRA? The purpose of MIRA is to contextualize both observations and model results through the encouragement of holistic projects and collaborations. Linking aerosol disciplines removes gaps in understanding that hinder our interpretation of observations and model results. Such linkages improve our understanding of air quality, weather, and climate.
How does MIRA differ from other working groups? MIRA focuses on interdisciplinarity to improve measurements and their utility, so MIRA complements the activities of other groups. Other interdisciplinary aerosol groups have different primary foci. For instance, AeroCom mainly focuses on improving global aerosol models, AeroSat focuses on strengthening collaboration amongst satellite aerosol retrieval groups, and ICAP focuses on aerosol forecasting. We hope that many MIRA projects engage these groups.

Shi, Yingxi

Investigating the spatial and temporal limitations of satellite characterization of wildfire smoke using satellite and airborne imagers during FIREX-AQ

Satellite aerosol products, especially geostationary (GEO) products, provides wide spatial and fine temporal data coverage. These satellite aerosol products are used in many studies to provide global data on biomass burning (BB) emissions. However, the capability of operational satellite sensors to properly characterize emissions from individual fire, given their spatial and temporal limitations, still requires further investigations. The Fire Influence on Regional to Global Environments and Air Quality (FIREX-AQ) experiment, over the Western U.S. during the summer of 2019, provided a great opportunity to evaluate the ability for satellite products to retrieve the spatial-temporal variability of smoke. Along with operational Moderate Imaging Resolution Spectroradiometer (MODIS) Dark Target (DT) aerosol product, we generated versions of DT products on two geostationary sensors (Advanced Baseline Imagers (ABI) on GOES-E and GOES-W) and an airborne sensor (the enhanced-MODIS simulator (eMAS) on the ER-2), using a modified version of DT algorithm, which aims to retrieve intense smoke plumes. Since the ER-2 often flew multiple tracks over individual fires, this provided a unique opportunity to observe the temporal variability of the resulting smoke. We specifically focused on retrievals over the Williams Flat Fire (northeast Washington State) on August 6-8, 2019, thereby exploring the spatial variability within and surrounding the smoke plumes at a variety of spatial and temporal resolutions. With multiple eMAS flight tracks and multiple GEO images over the same fire plume, we aim to quantify and generalize the ability of satellite aerosol products to represent BB smoke.

Skeie, Ragnhild

Aerosol Radiative Forcing in the AeroCom historical experiment

In this study, radiative forcing time series on a component basis from the AeroCom phase III historical experiment are presented. For each aerosol component (sulphate, black carbon, organic aerosols, nitrate) aerosol radiative forcing for aerosol-radiation interaction are calculated from 1850 to 2014 using a radiative kernel and modelled changes in aerosol mass. The radiative kernel has been generated using the DISORT radiative transfer model. The radiative forcing trend will be presented on a global and a regional scale. To complement the AeroCom experiments, the calculations are also done for model results from the CMIP6 historical experiment. Both the AeroCom phase III and CMIP6 historical experiment use the CMIP6 CEDS emissions. These emissions are recently updated. Using results from OsloCTM3, we show how the updated emissions have changed the radiative forcing trends in the model.

Smirnov, Alexander

Maritime Aerosol Network as a component of AERONET - an international collaborative effort

Aerosol optical depth is an atmospheric optical parameter critical for various applications ranging from Earth radiative balance computations to ocean color studies, from understanding of global aerosol distribution to aerosol remote sensing from space and global aerosol transport modelling. Maritime Aerosol Network (MAN) is a component of AERONET and deploys a hand-held sunphotometer (Microtops II) for optical depth measurements aboard ships of opportunity. Data collection over World Oceans, spanning now for over 15 years, has been successful because of close collaboration among various government institutions and universities in the US, UK, Germany, Poland, Canada, Russia, Saudi Arabia, Italy, South Africa, Namibia, Australia, and New Zealand. Current data archive consists of more than 650 cruises completed and overall over 7000 days of measurements are available. MAN provides instruments, calibration and processing. The major advantage of our activity is the fact that hand-held sunphotometer calibration and processing are tied to the AERONET standard. The data are in a public web-based archive and available for the scientific community at large. The collected data make an important contribution, enhance our knowledge and help better understand aerosol optical properties over the oceans. In this paper we will show the progress of the network, data usage for various applications and present opportunities for collaboration.

Sogacheva, Larisa

Towards harmonization of the ATSR and SLSTR AOD CDRs

Space-born systems provide a global view on atmospheric aerosols which have an important impact on climate, air quality and human health. Aerosol satellite products (e.g., aerosol optical depth, AOD) are widely used in climate studies and for model evaluation. Thus, there is a need for well-qualified, satellite-based, aerosol Climate Data Records (CDRs). A CDR is nominally required to contain a time series of 30 or more years. Individual satellite missions have shorter lifetimes; being typically designed for 5-7 years, but potentially lasting up to 15-20. Thus, a CDR must be built from multiple data records. Creating a fully consistent CDR from them is a challenging task. To minimize any possible offsets between AOD retrieved from subsequent generations of satellites, operational systems attempt to ensure continuity by launching a series of identical or almost identical sensors (e.g., Moderate Resolution Imaging Spectroradiometer (MODIS) and Visible Infrared Imaging Radiometer Suite (VIIRS); Along-track Scanning Radiometers (ATSR) and Sea and Land Surface Temperature Radiometer (SLSTR)). However, even for identical instruments (e.g., MODIS Terra and Aqua) their characteristics may change during launch and post-launch for example by optical degradation or orbital drift. SLSTR instruments on-board Sentinel-3 satellites (S3A in operation from 2017, and S3B in operation from 2018) evolved from the ATSR instruments on the European research satellite (ERS-2, ATSR-2, 1995-2012) and Environmental satellite (ENVISAT, AATSR, 2002-2012). ATSR and SLSTR instruments are built based on the same principles and dual-view capability. However, the ATSR forward view was replaced with a rearward ("oblique") view for SLSTR, which results in differences in viewing geometry. There are other differences between ATSR and SLSTR e.g., SLSTR has a wider swath, which allows better coverage and temporal resolution; a better spatial resolution (0.5 km against 1 km for ATSR); and possesses a 1.375 µm channel for cirrus detection. These are less critical, however, than the changes in viewing geometry and do not introduce systematic biases in the AOD product greater than the uncertainty in the retrievals themselves. This study is aimed to reveal agreement and differences between the ATSR and SLSTR AOD products and to study the possibility of building a monthly AOD CDR from the ATSR and SLSTR AOD. We foresee two main challenges in stitching a long-term aerosol record together: (i) a gap (2012-2017) between the ENVISAT and Sentinel-3 missions and (ii) the difference between ATSR and SLSTR in viewing geometry. Swansea University (SU) monthly aerosol products – ATSR Ver4.33 (1995-2011) and SLSTR SU Ver1.12 (2018-2020) – were utilized for a first analysis. The SLSTR SU retrieval algorithm is based on the same principles as the ATSR retrieval, with small differences related to the specific characteristics of the instruments. As bridging products, MODIS Terra DT&DB, MISR v32 and merged FMI v1.0 monthly AOD products were utilized. An approach for harmonization of the ATSR and S3A products on regional level was developed and tested. First, the ATSR and MODIS products for the bridging period were offset-corrected to S3A. Second, the S3A and MODIS products for the bridging period were offset-corrected to ATSR. Monthly AOD from the offset-corrected products were evaluated with AERONET.
First results from the harmonization of the ATSR and SLSTR AOD CDRs obtained in the context of the ESA COPA 4000133521/20/I-BG project (Fig.1) and further latest achievements will be reported.

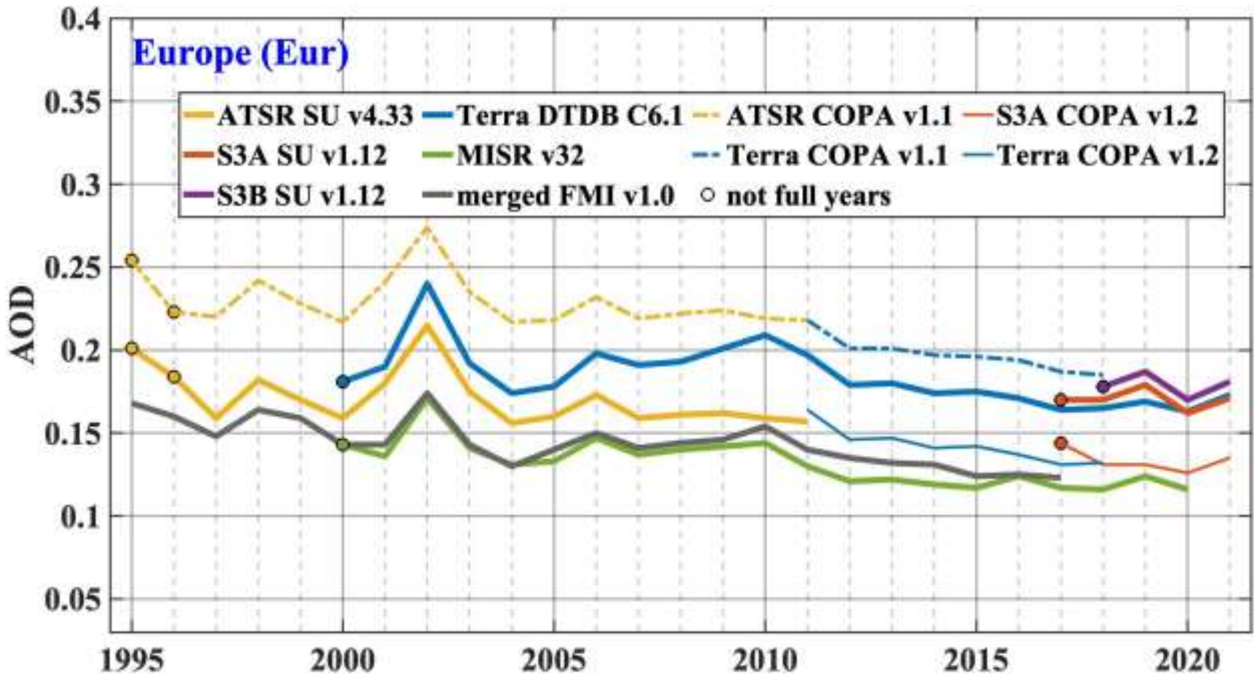

Figure 1 *For Europe, <u>with thick solid lines</u>, annual AOD time series from ATSR SU Ver4.33 (yellow), S3A SU Ver1.12 (red), S3B Ver1.12 (purple), MODIS Terra DTDB (blue), MISR v32 (green) and merged FMI v1.0 (grey) monthly AOD products; <u>with dashed lines</u>, ATSR (yellow) and MODIS (blue) AOD offset-corrected to S3A (ATSR and MODIS COPA v1.1); <u>with thin solid lines</u>, MODIS (blue) and S3A (red) offset-corrected (MODIS and S3A COPA v1.2) to ATSR. Not full years are marked with dot.*

Suchyta, Harrison

Emissions-MIP Phase 1b - a Climate and Chemistry Model Intercomparison Project

Emitting SO2 into the relatively pristine atmosphere over ocean basins may have a disproportionate effect on climate forcing. In a continuation of previous Emissions-MIP work, characterizing model sensitivities to assumed emission height, seasonality, and fraction of sulfur emitted as SO4 (Ahsan et al., this meeting), this project phase focuses on examining model sensitivity to ocean shipping emissions. We examine how different models respond to overall reductions in shipping SO2 emissions and shifts in the distribution of emissions between ocean basins. These tests provide insight into model sensitivity in the current era and the mid-20th century when background global SO2 emissions were lower and had a very different spatial pattern. We compare reported aerosol and gas concentrations, deposition rates, and radiative fluxes for each model simulation and determining where the greatest sensitivities exist for each model. This project quantifies how models respond to the magnitude and spatial distribution of shipping SO2 emissions and will guide efforts to improve emission data. This poster presents initial results from this ongoing comparison effort.

Takemura, Toshihiko

North Atlantic Warming Hole by reducing anthropogenic aerosols

The North Atlantic Warming Hole (NAWH) with decreasing temperature despite increasing carbon dioxide concentrations has been observed and predicted. If aerosols, which have a cooling effect on the atmosphere, decreased as a result of air pollution control, the NAWH may form as in the case of increased CO2 concentrations. In this study, sensitivity experiments using an aerosol climate model, MIROC-SPRINTARS, with a coupled atmosphere-ocean were conducted by varying the amount of anthropogenic sulfur dioxide emissions, a precursor of sulphate aerosol, to analyze the changes in the ocean temperature, salinity, and density as well as air temperature. The results showed that the spatial patterns of the NAWH due to the changes in SO2 emissions was similar to that due to the changes in the CO2 concentrations, but the magnitude of the changes in ocean parameters due to the changes in SO2 emissions is larger even when changes in global mean temperature are comparable.

Tsigaridis, Kostas

Simulating volcanoes of all scales with GISS ModelE

A summary of volcanic research using the GISS ModelE Earth system model will be presented. From mega-eruptions of the distant past to historical events affecting ancient civilizations, and a statistical approach to use ice-core data to infer more information from uncertain eruptions of the past, this presentation will demonstrate how we try to go beyond traditional volcanic research and expand our understanding of those violent events on the planet's climate.

van Diedenhoven, Bastiaan

An observational study on the vertical development of shallow cumulus and congestus clouds and its sensitivity to aerosol concentrations

Marine shallow cumulus and congestus clouds are important for radiation and the water cycle. Such clouds are particularly susceptible to aerosol and climate perturbations, but are generally not well represented by climate models. Combinations of observations and high-resolution models are needed to better understand the sensitivity of the micro- and macrophysical properties of cumulus and congestus clouds to aerosol and dynamics variations. Here, we use remote sensing and in situ observations from NASA's Cloud, Aerosol and Monsoon Processes Philippines Experiment (CAMP2Ex) to explore the microphysics of shallow cumulus and congestus as a function of altitude, aerosol loading and environment. We show that liquid water path generally scales with cloud top height squared as expected, while droplet number concentrations decrease rapidly with altitude. The droplet number concentrations for low cloud top heights are shown to highly correlate with aerosol number concentrations. For moderately high aerosol number concentrations, droplet size distributions widen as cloud top height increases and eventually generally develop a bi-model structure indicative of collision-coalesence processes. For very low aerosol number concentrations, wide droplet size distributions are observed at low cloud tops already indicating that in such cases collision-coalesence processes occur very early in the cloud lifecycle. We show that this may lead to an apparent increase of an observed aerosol activation fraction as a function of aerosol number concentration. In addition, we show that regional scale model simulations poorly represent the aerosol activation and microphysical properties of such clouds, likely because of unresolved vertical motion variations.

Veihelmann, Ben

The CEOS-AC PM2.5 whitepaper

Wall, Kasey

Assessing effective radiative forcing from aerosol-cloud interaction over the global ocean

The effect of anthropogenic sulfate aerosols on cloud radiative properties is one of the largest uncertainties in the radiative forcing of climate over the industrial era. This uncertainty limits our ability to predict equilibrium climate sensitivity (ECS) – the equilibrium global warming following a doubling of atmospheric CO_2. Here we use satellite observations to quantify relationships among sulfate aerosols and clouds while carefully controlling for meteorology. We then combine the relationships with estimates of the change in sulfate concentration since about 1850 to constrain the associated radiative forcing. We estimate that the cloud-mediated radiative forcing from anthropogenic sulfate aerosols is -1.11 ± 0.43 W m^{-2} over the global ocean (95% confidence). This constraint implies that ECS is likely between 2.9 and 4.5 K (66% confidence). Our results indicate that aerosol forcing is less uncertain and ECS is probably larger than the ranges proposed by recent climate assessments.

Wang, Zhili

Incorrect Asian aerosols affecting the attribution and projection of regional climate change in CMIP6 models

Watson-Parris, Duncan

Multi-model Perturbed Parameter Experiment update

I will update on both the Black Carbon and Cloud Multi-model Perturbed Parameter Experiments (MMPPEs) with particular emphasis on initial single model BC results, as constrained against Aeronet and in-situ aircraft observations. I will also discuss the one-at-a-time results of the Cloud MMPPE which already highlight important structural differences between UKESM, ECHAM-HAM and CESM.

Wilcox, Laura

The role of anthropogenic aerosol forcing in the 1850–1985 strengthening of the AMOC in CMIP6 historical simulations

Previous work has shown that anthropogenic aerosol (AA) forcing drives a strengthening in the Atlantic Meridional Overturning Circulation (AMOC) in CMIP6 historical simulations from 1850 to 1985. However, the mechanisms are not fully understood. We separate CMIP6 models into those with a ‘strong’ and ‘weak’ response to AA forcing, and show that the spread in AMOC changes are primarily caused by changes in turbulent heat fluxes over the sub-polar North Atlantic, rather than downwelling surface shortwave radiation. This increased turbulent heat flux cooling is largely a result of a colder and dryer atmosphere in models with strong AA forcing. In particular, we hypothesize that large AA driven cooling anomalies over North America are key for mediating this indirect AMOC response to AA forcing, via the advection of cold and dry air over the ocean. There is large uncertainty in the magnitude and distribution of aerosol effective radiative forcing in CMIP6. Understanding this uncertainty is important for the interpretation of simulated AMOC variability. For example, a comparison of key indices to observations suggests that the AMOC response in the 'strong' models may be too large. In this presentation, we will also briefly highlight areas where model diversity in the representation of aerosol processes may be particularly important for uncertainty in simulations of North Atlantic climate.

Witek, Marcin

Increasing the accuracy of MISR AOD retrievals over land at high aerosol loading

Multiangle Imaging SpectroRadiometer (MISR) multi-wavelength and multi-angle observations offer a unique capability for retrieving aerosol optical depth (AOD) and particle properties over most surface types, including land. The excellent quality of MISR aerosol retrievals has been documented in a number of studies. The current MISR land algorithm combines the benefits of two powerful approaches: (1) the heterogeneous surface algorithm (HET) that makes use of surface contrasts and empirical orthogonal functions to represent the surface bidirectional reflectance factors (BRFs), and (2) the homogeneous surface algorithm (HOMOG) that applies spectral and angular invariance constraints to the surface BRFs. HOMOG was introduced in 2005 to limit occasional outliers and unphysical region-to-region noise in basic HET AOD retrievals. Recently, extensive testing has shown that HOMOG works very well in the low- to medium-AOD range ($\lesssim$0.8), but its application under higher aerosol loadings is problematic due to reduced sensitivity to surface reflection. As a result, retrieved MISR AODs over land tend to become more and more underestimated as pollution levels increase. Here we report on a prototype MISR aerosol retrieval algorithm over land that alleviates this AOD underestimation at high aerosol loading. The improvements introduced to the basic HET algorithm do not require use of the HOMOG constraint at high AODs, thus removing the main cause for AOD underestimation. Simultaneously, the prototype algorithm shows very high AOD retrieval accuracy (quantitatively) as well as spatial consistency (qualitatively). The results are a testament to the physical principles and empirical prowess of the original multi-angle aerosol retrieval algorithm over heterogeneous surfaces.

Xue, Yong

Deriving a Global and Hourly Data Set of Aerosol Properties over Land Using Data from Geostationary Satellites

Due to the limitations in the number of satellites and the swath width of satellites (determined by the field of view and height of satellites), it is impossible to monitor global aerosol distribution using polar orbiting satellites at a high frequency. This limits the applicability of aerosol properties such as aerosol optical depth (AOD) and Single scattering albedo (SSA) data sets in many fields, such as atmospheric pollutant monitoring and climate change research, where a high-temporal data resolution may be required. AOD and SSA are important parameters affecting the radiative forcing of aerosol. However, current AOD and SSA retrieval only relies on several typical aerosol models, limiting the range of AOD and SSA variation. Although geostationary satellites have a high–temporal resolution and an extensive observation range, three or more satellites are required to achieve global monitoring of aerosols. In this article, we obtain an hourly and global AOD and SSA data sets by integrating AOD and SSA data sets from geostationary weather satellites. Various retrieval algorithms have been developed for different geostationary satellite sensors. The integrated data set will expand the application range beyond the individual AOD and SSA data sets. The analysis results show that the integrated AOD data set has similar accuracy to that of the MODIS/AOD data set and has higher temporal resolution and spatial coverage than the MODIS/AOD data set. The retrieved SSA products will be more helpful to characterize the aerosol absorption in the pollution on an hourly scale.

Yu, Hongbin

Updates on the AeroCom Phase III analysis of the global dust cycle and trans-Atlantic dust deposition (TADD)

Desert dust, one of the most abundant aerosols in the atmosphere, is recognized as an integral component of the Earth system that influences weather and climate via a suite of complex interactions with the energy, water, and carbon cycles. Dust storms also cause detrimental losses of human life and economic activities through degrading air quality, spreading diseases, disrupting transportation, and reducing efficiency of solar power generation. There has been growing attention in the past decades to advancing the research of dust cycle – a chain of processes involving emission, transport, transformation, and removal, and its tight coupling with other components of the system and human dimension. This study uses a suite of remote sensing (AERONET, MODIS, CALIOP, MISR, IASI) and in situ measurements of dust to evaluate 18 major chemical transport models from 15 international institutions participating in the AeroCom Phase III experiment. Major results from this multi-satellite and multi-model analysis include: (1) although significant progresses have been made over the past decade, the models are still highly diverse in simulating the dust cycle; (2) the simulated dust optical depth (DOD) shows the best agreement with each other and with observations; however, constraining global DOD is far from adequate for assessing the roles of dust in the Earth system; (3) the models differ substantially in characterizing dust size distributions, which drives large spread in estimates of dust emissions and deposition; and (4) improvements on dust removal parameterizations are needed for both wet and dry processes.

Yu, Yan

Enhanced dust emission following large wildfires due to vegetation disturbance

Large wildfires reduce vegetation cover and soil moisture, leaving the temporally degraded landscapes an emergent source of dust emission. However, the global extent of post-fire dust events and their influencing factors remain unexplored. Using satellite measurements of active fires, aerosol abundance, vegetation cover and soil moisture from 2003 to 2020, here we show that 54% of the examined ~150,000 global large wildfires are followed by enhanced dust emission, producing substantial dust loadings for days to weeks over normally dust-free regions. The occurrence and duration of post-fire dust emission is controlled primarily by the extent of precedent wildfires and resultant vegetation anomalies and modulated secondarily by pre-fire drought conditions. The intensifying wildfires and drying soils during the studying period have made post-fire dust events one day longer, especially over extratropical forests and grasslands. With the predicted intensification of regional wildfires and concurrent droughts in the upcoming decades, our results indicate a future enhancement of sequential fire and dust extremes and their societal and ecological impacts.

Zhang, Kai

On the regional differences in cloud and precipitation responses to anthropogenic aerosol perturbations through fast processes

Clouds and anthropogenic aerosols both have very heterogeneous geographical distributions. Clouds form where there is more moisture than what the air can hold, while anthropogenic aerosols (with different compositions) are concentrated near the source and the downwind regions. Consequently, the cloud and precipitation responses to anthropogenic aerosol (or cloud condensation nuclei, CCN) perturbations are regionally dependent. Using a global aerosol-climate model, we find large regional differences in the slope between the relative changes (between clean and polluted conditions) in the simulated cloud and aerosol quantities. For example, the slope between the relative changes in liquid water path and CCN in the NH polar region is about a factor of 3 larger than that in the tropics. These regional differences also vary in time, because of regional composition changes and shifts in the emission regions of anthropogenic aerosols. Preliminary analysis shows such large regional differences also exist in other global aerosol-climate models, although (as expected) there is a large diversity in the simulated regional patterns and the temporal evolution. Understanding the impact of such regional differences in various models is important to quantify the uncertainty in estimating the anthropogenic aerosol effect on climate change.

Zhong, Qirui (Schutgens, Nick)

Using modelled relationships and satellite observations to constrain aerosols over biomass burning regions

Biomass burning (BB) is a major source of aerosols that remain the most uncertain components of the global radiative forcing. Current global models have great difficulty matching observed aerosol optical depth (AOD) over BB regions, which hinders the understanding of the net climate impact of aerosols. A common solution to obtain models in line with observations is scaling BB emissions. Using the relationship from an ensemble of aerosol models and satellite observations, we show that the bias in aerosol modelling results primarily from incorrect lifetimes and underestimated mass extinction coefficients. In turn, these biases seem to be related to incorrect precipitation and underestimated particle sizes. In total, these factors contribute more (49% ± 21%) to the overall mismatch with AOD than errors in emissions (38% ± 18%). A relevant work focusing on AAOD also highlighted the bias in particle sizes and precipitation, with additional bias resulting from the refractive index. We further show that boosting BB aerosol emissions to align the modelled AOD with the measured AOD over the source region causes an overestimation of AOD in the outflow from the key BB continent Africa by 48%, leading to a double warming effect compared with when biases are simultaneously addressed for both aforementioned factors. Such deviations are particularly concerning in a warming future with increasing emissions from fires.