chlorine measurements, along with measurements of HCl and total inorganic chlorine, $Cl_y$, enable the first analysis of the inorganic chlorine budget in the Arctic vortex. The results indicate excellent agreement between the sum of the measured species (ClO + 2×ClOOCl + $ClONO_2$ + HCl) and $Cl_y$ in January and early February; however, the budget agreement becomes significantly worse during early to mid-March. The source of the March budget discrepancy is explored, revealing evidence that supports the validity of the ClO, ClOOCl, and $ClONO_2$ measurements. The BrO measurements represent a substantial improvement in sensitivity, precision, and spatial resolution relative to those acquired previously onboard the ER-2. Modifications to the BrO detection system, laboratory calibrations, and analysis of *in situ* BrO data successfully obtained during twelve flights of the 1999-2000 winter are presented. The Harvard Halogen instrument is currently being modified to include IO detection capabilities. The observed long-term trend in mid-latitude Northern Hemisphere ozone in the lower stratosphere over the last two decades may be the result of increased catalytic loss of ozone by the rate-limiting halogen radicals ClO, BrO, and IO. This makes measuring all three of these halogen oxides critical. The motivation and method of IO detection will be discussed. Specifically, measuring IO *in situ* requires the sensitivity to detect sub parts per trillion concentrations. Based on the known laser characteristics of the OH and $NO_2$ laser systems used in this laboratory and the known collection efficiency of the detection optics, we expect a sensitivity of better than $10^5$ $cm^{-3}$ for IO.

### A32B-0153 1330h POSTER

## Contrail Layer Forecasts for Fairbanks, Alaska

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The condensation trail (contrail) layers for the subarctic setting of Fairbanks have been analyzed and forecasted based on atmospheric sounding measurements and vertical profiles derived from the MM5 mesoscale atmospheric circulation model. An operational contrail observation site was established in 2001 for verification. Using an improved Schmidt-Appleman criterion the contrail formation was confirmed for the majority of our observations. Without taking into account different aircraft types we derived a success-rate of 0.91 for the near real-time contrail analysis when using an average aircraft specific contrail factor of 0.0365 g/kg K. Forecasts of contrail layers could be involved in flight planning in order to avoid contrail formation and corresponding possible climatic effects. High correlation was found for the comparison of the 6 hour ($r \sim 0.94$) and 30 hour ($r \sim 0.88$) forecasts of contrail layer boundaries with the boundaries derived from atmospheric sounding for the period from February until July 2003.

URL: http://contrail.gi.alaska.edu/

### A32B-0154 1330h POSTER

## In-Situ Stratospheric Observations of a Volatile Component in Rocket Exhaust Aerosol Particles.

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Aerosol in the plume wake of an Athena II solid fuel rocket was sampled between 16 and 19 km altitude using a two channel laser particle counter with heated and unheated sample inlets and carried by the WB-57F aircraft during the ACCENT campaign. Total and non-volatile aerosol size distributions were obtained for particles with diameters between 360nm and 4100nm during five plume encounters up to 45 minutes after launch. The average fraction of the total aerosol volume accounted for by the volatile component for all of the encounters was 66±19, approximately constant for all of the encounters. Persistence of the volatile component until the last plume encounter 45 minutes after launch, along with other recent models and observations of rocket plumes, suggest that the composition of the volatile component was primarily water ice and HCl with a surface layer of HNO3. In this view, a thin HNO3 layer suppresses ice evaporation and so accounts for the unexpectedly long lifetime of the plume volatile aerosol. Our data strongly reinforce previous work suggesting that rocket plumes contain HNO3 coated ice particles and so are more reactive than has been widely assumed.

### A32B-0155 1330h POSTER

## A 3D model study of the influence of nitric acid uptake onto ice particles

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The chemistry in the upper troposphere is critically dependent on the availability of $NO_x$. Lawrence and Crutzen (Tellus, 50B, 263-289, 1998) proposed that denitrification via efficient uptake of nitric acid ($HNO_3$) on ice particles and their subsequent gravitational settling could significantly perturb upper tropospheric chemistry. Despite several laboratory and field studies, the degree to which $HNO_3$ is taken up by ice or retained upon freezing of supercooled droplets is still uncertain. In this study we investigate the sensitivity of upper tropospheric chemistry to variations within the range of current uncertainties using the 3D global chemistry transport model MATCH-MPIC. Recent uptake models of $HNO_3$ on ice have been included in the model. Associated key assumption used in the general model formulation such as effective settling velocity of ice particles or ice water contents are also reevaluated in light of recent observations. The results are compared with aircraft observations of gas-phase $HNO_3$ in order to put constraints on the model assumptions. The influence of these assumptions on upper tropospheric $HO_x$ and ozone are also evaluated.

# A32C MCC: 3018 Wednesday 1340h

## Integrating Aerosol Measurements and Models VI *(joint with OS, GC)*

***Presiding:*** **K A Prather,** University of California, San Diego**; S Kinne,** Max-Planck-Institut für Meteorologie

### A32C-01 1340h INVITED

## Atmospheric Brown Clouds: An Integrated Approach for Understanding their Climate Impacts

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The most visible impact of air pollution is the haze, a layer of pollutants and particles from biomass burning and industrial emissions. This cloud of pollution at times has a brownish color and this brown cloud phenomenon is a common feature of industrial and rural regions around the world. Due to long range transport, the mostly urban (fossil fuel related) or rural (biomass burning related) phenomenon is transformed into a regional haze (or cloud) that can span an entire continent. e.g., the Asian Brown Cloud or an entire ocean basin (e.g., N. Atlantic). It is now becoming increasingly clear that the brown cloud has dimmed the planet at the surface, while simultaneously making it brighter at the top, which can have large impacts on Agriculture, health, climate and the water budget of the planet. We use model results and observed precipitation records to suggest that this dimming effect could have contributed to drying of the planet. My talk will describe the discovery of the Asian Brown Cloud during the INDOEX experiment and subsequent modeling studies that link this cloud with global drying and disruption of regional climate including the S. Asian monsoon, amongst other impacts. These major advances were made possible by a unique approach that integrated surface, aircraft and satellite measurements with aerosol chemical, micro physical and assimilation models. I will conclude with a new experimental approach for solving this major global environmental problem.

### A32C-02 1410h

## Analysis of Measurement Requirements for the Aerosol Indirect Effect: A Synthesis of Observations and Modeling

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The aerosol indirect effect has been measured for some time now by satellite remote sensors, and more recently by surface-based remote sensors. The indirect effect is often expressed in terms of a relative change in drop size for a relative change in aerosol optical depth or extinction. Here we present some recent results of surface based remote sensing of the indirect effect and assess whether aerosol optical depth or extinction is a suitable proxy for the aerosol affecting drop formation. To do so, we use multiple realizations of a cloud model to investigate the sensitivity of cloud drop effective radius $r_e$ to aerosol parameters (size distribution and composition) and dynamical parameters (updraft and liquid water content). A breakdown of the individual aerosol terms contributing to drop size change shows that use of aerosol extinction as a proxy for size distribution and composition tends to underestimate the magnitude of the first indirect effect. The use of the aerosol index alleviates this problem somewhat. We show that $r_e$ is most sensitive to cloud liquid water, a parameter often ignored in indirect effect analyses. The relative importance of the other parameters varies for different conditions but aerosol concentration $N_a$ is consistently important. Updraft plays an increasingly important role under high aerosol loadings. Requirements for measuring the indirect effect over polluted continents are shown to be more stringent than those over cleaner, remote oceans. This may influence interpretation of current satellite and surface remote measurements of the indirect effect.

### A32C-03 1425h

## Response of the coupled climate system to aerosols simulated with a MODIS aerosol assimilation

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Recent observational and modeling studies have shown that absorptive aerosols can have significant effects on regional climate and the hydrological cycle. The effects of aerosols on the global climate system are simulated using the new NCAR Community Climate System Model (CCSM3) forced with aerosols from a novel aerosol assimilation. The aerosol assimilation produces global distributions of sea-salt, sulfate, carbonaceous aerosols, and soil dust constrained by satellite observations. The satellite observations are aerosol retrievals from the MODIS (Moderate Resolution Imaging Spectroradiometer) instrument on the NASA Aqua and Terra satellites. The analysis spans a three-year period from March 2000 to February 2003. The effects of aerosols are demonstrated by comparing CCSM integrations with no aerosols, no absorbing aerosols, and all aerosols. The differences in global mean surface temperature are consistent with the climate sensitivity of the CCSM to changes in well-mixed greenhouse gases. The results show statistically significant changes in surface temperature, surface energy fluxes, boundary layer structure, and precipitation. The fraction of these signals related to the presence of absorbing aerosols is quantified using the simulations with no aerosol absorption.

### A32C-04 1440h

## New Measurements of Aerosol Vertical Structure from Space Using the NASA Geoscience Laser Altimeter System (GLAS): Applications for Aerosol Transport Models

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In the past, satellite measurements of aerosols have only been possible using passive sensors. Analysis of passive satellite data has lead to an improved understanding of aerosol properties, spatial distribution, and their effect on the earth's climate. However, direct measurement of aerosol vertical distribution has not been possible using only the passive data. Knowledge of aerosol vertical distribution is important to correctly assess the impact of aerosol absorption, for certain atmospheric correction procedures, and to help constrain height profiles in aerosol transport models. On January 12, 2003 NASA launched the first satellite-based lidar, the Geoscience Laser Altimeter System (GLAS), onboard the ICESat spacecraft. GLAS is both an altimeter and an atmospheric lidar, and obtains direct measurements of aerosol and cloud heights. Here we show an overview of GLAS, provide an update of its current status, and discuss how GLAS data will be useful for modeling efforts. In particular, a strategy of using GLAS to characterize the height profile of dust plumes over source regions will be presented, along with initial results. Such information can be used to validate and improve output from aerosol transport models. Aerosol height profile comparisons between GLAS and transport models will be shown for regions downwind of aerosol sources. We will also discuss the feasibility of assimilating GLAS profiles into the models in order to improve their output.

URL: http://glo.gsfc.nasa.gov

### A32C-05 1455h

## IN SITU AEROSOL SIZE DISTRIBUTIONS AND RADIATIVE CLOSURE STUDY DURING AEROSOL INTENSIVE OPERATION PERIOD (ARM-IOP)

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During the Aerosol Intensive Operation Period of the Department of Energy's Atmospheric Radiation Measurement (ARM) program, the microphysical, chemical, and radiative properties of atmospheric aerosol were characterized in detail at ARM Southern Great Plains (SGP) site in north central Oklahoma in May, 2003. A differential mobility analyzer and an optical particle counter measured aerosol size distribution from 25 nanometers to several microns. Aerosol chemical composition and hygroscopicity were characterized using a Particle Into Liquid Sampler and a high flow tandem differential mobility analyzer system, respectively. Combined with the chemical composition and hygroscopicity measurements, aerosol size distributions measured were used to predict a wide range of aerosol optical properties and compared to the simultaneous direct measurements. This closure study allows one to assess the validity of the physicochemical description of the aerosol when closure is achieved, and also provides insight into potential sources of error when some or all of the comparisons result in disagreement.

### A32C-06 1510h

## Suborbital measurements of spectral aerosol optical depth and its variability at sub-satellite-grid scales in support of CLAMS, 2001

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As part of the Chesapeake Lighthouse and Aircraft Measurements for Satellites (CLAMS) experiment, July 10 - August 2, 2001, the 14-channel NASA Ames Airborne Tracking Sunphotometer (AATS-14) was operated aboard the University of Washington CV-580 during 10 research flights (45 flight hours). Among others, CLAMS research goals included validation of satellite-based retrievals of aerosol properties. AATS-14 measures the direct solar beam transmission at 14 discrete wavelengths (354-1558 nm), yielding aerosol optical depth spectra and columnar water vapor for such validation purposes. Comparisons of AOD between the AERONET Cimel instrument at COVE and airborne measurements by AATS-14 in its vicinity showed good agreement with largest r-square correlation coefficients at wavelengths of 380 and 500nm (>0.99). Coordinated low-level flight tracks of the CV-580 during Terra overpass times permitted validation of over-ocean MODIS level 2 (MOD04_L2) multi-wavelength AOD data (10x10km, nadir) in 16 cases on 3 separate days. While the correlation between AATS-14 and MODIS-derived AOD was poor with an r-square of 0.55, almost 75% of all MODIS AOD measurements were still in the desired uncertainty range ($\pm 0.03 \pm 0.05$*AOD). This may be due to the small AODs (generally less than 0.1 at 500nm) encountered in these comparison cases. An analogous coordination exercise resulted in 7 exact over-ocean match-ups between AATS-14 and MISR measurements. The comparison between AATS-14 and the MISR standard algorithm regional mean AODs showed a much stronger correlation with an r-square of 0.94. However, MISR AODs were systematically higher than the corresponding AATS values, with an rms difference of 0.06. AATS data collected during nine extended low-level CV-580 flight tracks were used to assess spatial variability in AOD at horizontal scales up to 100 km. At UV and mid-visible wavelengths, the largest absolute gradients in AOD were 0.1-0.2 per 50 km horizontal distance. In the near IR, analogous gradients rarely measured 0.05. On any given day, the relative gradients in AOD were remarkably similar for all wavelengths, with maximum values of 70% per 50 km and more typical values of 25%. We will discuss the implications of these unique measurements of AOD spatial variability for common validation practices of satellite data products and for comparisons to large-scale aerosol models.

### A32C-07 1525h

## Modeling Radiative Forcing by Aerosols: How Good is Good Enough?

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Radiative forcing of climate change by anthropogenic aerosols is now recognized as the largest uncertainty in climate forcing $F$ over the industrial period. This uncertainty limits inference of Earth's climate sensitivity $\lambda$ either empirically or by comparison of observed temperature change over the industrial period $\Delta T$ with modeled temperature change obtained by imposing a time-dependent forcing in a climate model. Either way, for a desired uncertainty in $\lambda$ of, say, 30% (e.g., temperature increase resulting from doubling atmospheric $CO_2$ $\Delta T_{2x} = 3 \pm 1$ K), the required uncertainty in $F$ is about 20%. The resultant required uncertainty in aerosol forcing depends on the magnitude of this for cing. If total aerosol forcing is small, the requisite uncertainty can be quite large, e.g., a factor of 2 for aerosol forcing -0.4 W $m^{-2}$. However as aerosol forcing magnitude increases the requirement is much more stringent, e.g., for aerosol for c ing -1.2 W $m^{-2}$, 10%, comparable to present uncertainty in greenhouse gas forcing. This talk examines quantifiable uncertainties in aerosol forcing and apportions them between contributions from atmospheric chemistry, atmospheric radiation, and c l ou d microphysics. Unless and until present uncertainties are greatly reduced it will not be possible to place confident limits on Earth's climate sensitivity, limiting society's ability to confidently plan to adapt to or mitigate future climate chang e arising from increasing atmospheric concentrations of greenhouse gases. n

URL: http://www.ecd.bnl.gov/steve/schwartz.html

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# A32D MCC: 3018 Wednesday 1600h

## Integrating Aerosol Measurements and Models VII *(joint with OS, GC)*

***Presiding:*** **J Penner,** University of Michigan**; S Kinne,** Max-Planck-Institut für Meteorologie

### A32D-01 1600h

## THE AEROCOM PROJECT: DIAGNOSTIC OF AEROSOL MODULES IN GLOBAL MODELS

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Aerosol introduces one of the larger uncertainties in climate modeling. This led to new efforts in the global modeling community to represent aerosol properties and processes in more detail (including interactions with chemistry and clouds). With a distinction among different aerosol types, new untested assumptions were made and need to be evaluated, preferably to measurements. The AeroCom project http://nansen.ipsl.jussieu.fr/AEROCOM seeks to document differences of aerosol component modules (of global models) and to assemble useful data-sets for model evaluations. AeroCom's overall goals are the identification of weak components in aerosol modeling and an assessment of current uncertainties with respect to simulated aerosol optical properties and the associated radiative forcing. AeroCom participation is still open to any aerosol-component global modeling group and any measurement-groups, which measure properties relevant to simulated aerosol properties and aerosol parameterizations. First results on unified data-sets and on model performance will be presented.

URL: http://nansen.ipsl.jussieu.fr/AEROCOM

### A32D-02 1615h

## AEROCOM - First Results from the Global Aerosol Model Intercomparison Project

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