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Title: Update on Giovanni for Aura Products

In this presentation we provide an update on the latest capabilities and data additions to Giovanni. Giovanni, an online data exploration tool developed at the NASA Goddard Earth Sciences (GES) Data Information Services Center (DISC), provides easy access to multi-satellite data with extensive data analysis capabilities (http://giovanni.gsfc.nasa.gov). Users no longer have to worry about downloading large data sets, data formats, or installing tools for visualization. Giovanni provides capabilities of displaying and subsetting "good" quality Level-2G data (as recommended by science teams) in addition to the Level-3 gridded data, in ASCII or HDF format.

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Title: Gravity Wave Events in HIRDLS Temperature Profiles

The high vertical resolution and horizontal resolution along the measurement track afforded by HIRDLS sampling illuminates detailed structure of gravity wave events in HIRDLS temperature data. We present example events as well as collocated measurements from nearest-neighbor HIRDLS and MLS measurements. The latter view the locations of the HIRDLS gravity wave events at different times and viewing angles. The results show the dependence on these viewing parameters and are interpreted in terms of wave propagation direction, wave event intermittency, and instrument resolution.

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Title: Looking at the Springtime Troposphere and Lower Stratosphere over the Central North Pacific Through Many Pairs of Glasses: An INTEX-B Case Study using an AURA Validation Science Paradigm

During the recent Intercontinental Chemical Transport Experiment – Phase B (INTEX-B) aircraft intensive, the NASA DC-8 flew from Oahu, Hawaii to Anchorage, Alaska with the science objectives of characterizing the Central Pacific upper troposphere and lower stratosphere, and of obtaining correlative data for the TES and HIRDLS satellite instruments. The Pacific transect flight took place on May 1, 2006, capturing a picture of the atmosphere during an interesting synoptic-scale flow pattern, ideal for testing our ability to answer tough science questions by combining satellite observations with remote and in situ aircraft data. The DC-8 flew in the upper troposphere at 240-215 mb during most of the flight, passing from the tropics through a cut-off low, and then crossing the polar jet and into the stratospheric “middle world”. TES satellite observations provide the big picture of Central Pacific carbon monoxide (CO) and ozone (O3) distributions in a larger global context. Two ozone lidars operating on the DC-8 reveal both filamentation and wave structure in troposphere and

lower stratosphere that is associated with the major dynamical features. In situ air sampling reveals pollution layers in both the upper troposphere and the middle world, and small filaments of stratospheric air mixed in to the upper troposphere near the cutoff low. This case provides a context for exploring how different measurements see sharp horizontal and vertical ozone gradients, how inhomogeneity might be observed at differing spatial scales, and addresses the question of how very different data sets can be combined to characterize multi-scale processes, such as the exchange of air between stratosphere and troposphere.

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Title: Utilization of the Aura HIRDLS Spacecraft Pitch Maneuvers

During the Aura mission to-date there have been seven Aura spacecraft pitch maneuvers and an eigth is due early November 2006. These maneuvers pitch up the HIRDLS telescope boresight so that the background signal of space is seen over the complete scan range. The spatial and temporal dependent radiance signal from the 21 HIRDLS detectors during the maneuver is used to characterize the emission from the obstruction in the telescope and validate the method adopted. In the past this has helped in the selection of optimum scan patterns used for the normal science acquisition mode. The salient attributes of the pitch are presented and the main aspects of the data and how they are used is described.

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Title: OMI UV1 Residuals for Validation

A multichannel off-nadir ozone profile algorithm has been developed based on the version 8 TOMS and SBUV algorithms. The internal radiative transfer model was reworked to accomodate off-nadir viewing geometries. The profile retrievals show good agreement with NOAA-16 SBUV/2 data and reasonable agreement with AURA/MLS. The numerical performance of the algorithm has been tested against a very slow TOMRAD-based full retrieval method using synthetic data. The algorithm also has been tested with OMI L1B data, preliminary residuals from UV1 detector will be presented. Currently the selection of an optimal subset of channels based on instrument performance, effect of using temperature data from the NCEP GDAS analysis and the use cloud top pressure products from OMI are being investigated. Improvements are planned in advance of the public release of the OMI L1B datasets and GOME-2 data. The running time of the algorithm should be sufficient to allow most of the OMI and GOME-2 data to be processed.

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Title: Simulations of atmospheric composition using GEOS-4: evaluation with EOS-Aura data

Features of the composition of the middle atmosphere retrieved from EOS-Aura instruments will be

used alongside model simulations to interpret features of the atmospheric state. The model is a version of NASA's GEOS-4 GCM, with a representation of stratospheric chemistry. The meteorological fields are constrained with time-filtered analyses performed in GMAO. The paper will present comparisons of large-scale features, such as hemispheric distributions of long-lived trace gases, followed by analysis of structures in and around the polar vortices. Based on the comparisons, we will assess the credibility of the model as a tool for diagnosing processes that cause the observed chemical distributions. We will pay particular attention to the representation of transport and mixing in the polar regions and their impacts on denitrification in the model.

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Title: OMI Total Ozone Using the TOMS V8 algorithm- Status & plans

We will discuss the quality of the total ozone product from OMI produced using the TOMS version 8 algorithm. Our presentation will include algorithmic errors common to both TOMS and OMI, as well as OMI-specific instrument related errors. We will also discuss the plans for TOMS V9 algorithm, scheduled to be released next year. This algorithm will incorporate lessons learned by comparison of total ozone data produced using several different algorithms applied to TOMS, SBUV, GOME and OMI, as well as improvements to the various climatologies used in TOMS V8. TOMS V9 will be used to reprocess all TOMS and OMI data dating back to Oct 1978.

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Title: SAUNA - Sodankylä Total Ozone Intercomparison and Validation Campaign

After nearly thirty years of experience in comparing space-borne total ozone column measurements with ground based measurements, large differences remain at high-latitudes under conditions of low sun. These persistent ozone column differences are likely due in part to the problems with the absolute accuracy of the groundbased measurements, in part to observational differences between satellite and groundbased techniques, and in part to problems with the accuracy of the various satellite algorithms. Improved accuracy in the groundbased high-latitude/high solar zenith angle measurements of ozone, which is the goal of the SAUNA campaign. This will lead to improved satellite ozone measurements, and also to better understanding of the processes that contribute to the eventual recovery of the ozone layer.

The primary objective of the Spring 2006 Sodankylä total ozone intercomparison and validation campaign (SAUNA) is to establish a groundbased instrument and algorithm baseline using standard network instrumentation to retrieve the total column ozone to within one percent under these difficult measurement conditions. The other objective of SAUNA is to support the ongoing validation of the EOS-Aura HIRDLS, MLS, OMI and TES, the ERS-GOME, the Envisat-Sciamachy and SCISAT MAESTRO and FTS instruments, by performing satellite coincident measurements. An overview of the campaign and results are going to be presented.

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Title: Aura profiler validation using small balloon soundings

The validation of the EOS-Aura HIRDLS, MLS, and TES instruments is investigated using small balloons soundings for the Aura mission. Focus is given to the intensive campaigns funded specifically for Aura validation, including the 2006 ARM, SAUNA and WAVES intensive launch campaigns. Results will be presented for ozone, water vapor and temperature profiles in the troposphere and lower stratosphere.

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Title: Contribution of emissions from Indonesia/Australia to the distribution of pollution in the southern tropics during November 2004

We investigate the role of emissions in the Indonesia/Australia region on the distribution of pollution in the tropical Atlantic during November 2004 using observations of tropospheric ozone and carbon dioxide from the Tropospheric Emission Spectrometer (TES) in conjunction with additional satellite observations, in-situ measurements, and modeling analysis. Based on Sciamachy aerosol index and MODIS fire counts, we find evidence of elevated biomass burning in the Indonesia/Australia area relative to South America and sub-equatorial Africa. This finding is supported by observations of NO2 from Sciamachy, observations of carbon monoxide from TES, MOPITT, and AIRS, and observations of LIS lightning flash counts. Furthermore, comparisons of TES ozone over the tropical Atlantic with a SHADOZ ozone climatology and model runs from GEOS-Chem indicate an unexpectedly high ozone concentrations over Australia/Indonesia. The role of surface emissions in this enhancement are addressed by estimating global emissions in GEOS-Chem constrained by TES observations through a linear Bayesian synthesis technique. Based on this estimate, we investigate the sensitivity of tropospheric ozone to changes in emissions in the tropical Atlantic. In particular, we find that enhanced upper tropospheric ozone distributions over Indonesia/Australia seen from TES can be explained principally by convection from local emissions. Consequently, surface emissions from Indonesia/Australia may play a more important role in the distribution of sub-equatorial tropical ozone, particularly during northern hemispheric Fall time periods.

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Title: OMI Aerosol Products and Validation

What is the role of aerosols in climate change\? Answering this question is one of the science goals of OMI. To this end, the aerosol index, aerosol optical thickness, and single-scattering albedo are retrieved from the near-ultraviolet and visible spectra that are obtained by OMI. Two approaches to the aerosol retrieval are discussed. The near-ultraviolet method, which uses three wavelengths, is a

continuation of the method that has been applied to TOMS observations for many years. The multiwavelength method extends the near-ultraviolet method to up to seventeen wavelengths. Similarities and differences between the methods will be discussed. Both products are validated using ground-based data (AERONET) as well as satellite data (MODIS, POLDER). First results of the validation will be presented and discussed in terms of possible improvements to the algorithms.

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Title: Satellite Aerosol Validation using KNMI-GLOBE data

Within the GLOBE Aerosol Programme, high school students perform sun photometer measurements of the aerosol optical thickness (AOT) at two wavelengths as part of their science curriculum. The Dutch contribution to the GLOBE Aerosol Programme represents the largest student-based aerosol monitoring project in the world. This contribution is a collaboration between KNMI, SME Advies, and the GLOBE Programme.

In the previous years, more than 400 measurements over 12 locations were performed. These data were compared with MODIS and Aeronet data, and shown to be sufficiently sound for validation of MODIS data over five Dutch locations. We conclude that MODIS overestimates AOT at low values, and underestimates AOT at high values over land, while in coastal areas, MODIS overestimated AOT in general (Boersma and De Vroom, accepted for publication in JGR).

Starting in September 2006, the GLOBE efforts in the Netherlands will increase substantially. They are part of an educational module on Aerosols and UV, which will be offered as option to all 670 secondary schools by September 2007, within the framework of the official curriculum for the high school exams. We expect that the number of schools measuring aerosols will increase over the next 1.5 years to about 100.

The module teaches school children about aerosols in general, the importance of UV radiation, the underlying physics, and satellite observations. Part of the module is that student's measure with the sun photometer. KNMI provides the scientific input, including instrument calibration and quality control, and trains teachers in doing the measurements, so they can teach their pupils. We also maintain a website with the AOT results, based on an improved algorithm that also corrects for actual ozone columns (from SCIAMACHY).

The GLOBE data from the coming years will be used for validation of OMI AOT over the Netherlands. With data from about 70 schools over a country of about 200 x 300 km, we expect to have a dense network of regular measurements, which is not available from more professional instruments.

Besides the educational task, the GLOBE-KNMI programme also addresses outreach, by promoting science to students, and indirectly by generating press interest for GLOBE and thus also for satellite research.

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Title: NO2 Verification and Validation

Overviews will be presented of the status of the two available OMI NO2 products, namely the

operational NO2 level 2 product ("OMNO2" by NASA-KNMI, public release expected soon) and the Near-Real Time product ("level 4" by KNMI, plots daily at www.temis.nl). Both are based on NO2 operational slant columns, differ in airmass factors, surface albedo, NO2 under clouds.

The level 2 data will be scrutinized using a correlation tool developed at KNMI ("CAMA"), which can be used to reveal correlations between various parameters.

Verification and validation studies will be presented based on comparisons with groundbased MAXDOAS, SAOZ, Brewer data, and with SCIAMACHY NO2.

We will also investigate the validity of the assumed NO2 profiles, which influence the airmass factors, using NO2 profiles from airborne measurements during the INTEX-B campaign.

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Title: Validation of OMI Ozone Columns Derived Using the DOAS Algorithm (OMDOAO3) With Groundbased Brewer and Dobson

During the OMI mission, ozone column measurements have been regularly compared with groundbased columns measured by Brewer and Dobson. Earlier results have shown an average bias between groundbased and OMDOAO3 version 0.94 measurements of about 1.5 percent.

Recent reprocessing of the OMI data (version OMDOAO3 1.01, available for data from October 2005) has taken place. We will study the dependence of these updated OMI ozone data on latitude, longitude, solar zenith angle, ground albedo, and various other parameters, by an updated comparison with more than seventy groundbased Brewer and Dobson stations.

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Title: Understanding diurnal and seasonal variations in OH and HO2

The MLS instrument has been obtaining daily, near global observations of OH and HO2 for nearly two years. These data have given us new insight into the long standing HOx dilemma and ozone deficit problem. The results from the Sept. 2004 New Mexico validation campaign allow us to compare the satellite observations to those from the FIRS-2 and BOH balloon borne instruments. Two ground based instruments, FTUVS and PEPSIOS, measured the full OH column during this same time period. We compare the results from this suite of instruments to photochemical model results constrained by MLS observations of HOx precursor species. We'll discuss possible changes to the reaction kinetics that result in improved agreement between modeled and measured HOx as well as the implications of these changes for the HOx dilemma and ozone deficit problems.

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Title: Animated space-time analyses of Continental ozone, scales of variation, and implications for smog ozone retrieval

We present results emphasizing non-coincident validation techniques for the Aura Ozone products, viz, OMI-MLS and TES. These concentrate on animated maps of ozone across North America. Where feasible, we concentrate on lower tropospheric ozone from ~1.5 to 3.5 km, in regions where the layer shares many characteristics of the polluted boundary layer. DIAL Lidar analysis suggests spatial autocorrelation timescales for detailed features of such smog ozone, and also remotely sensed species like HCHO and NO2 which are very closely related to the ozone formation rate. The IONS sondes of 2004 and 2006 and auxiliary information provide information on temporal autocorrelation of lower tropospheric ozone. The IONS sondes provide coarse-resolution maps of lower tropospheric ozone across North America, and the maps seem to reveal broad-scale features (not easily diagnosed from the DIAL analysis) moving in patterns across continent). We will compare these to the views available from the satellite techniques. Understanding of combined spatial/temporal correlation is helpful not only for validation but also for filling data gaps, due, e.g., to clouds. A brief report on sonde data fresh from our field site at Calexico, California, evaluates the idea that smog ozone is better sensed in the American Southwest, where boundary layers can become very deep, and both thermal and IR techniques may sense more effectively.

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Title: Intercomparisons of total column ozone measurements from OMI(TOMSV8),OMI(DOAS), and MOD(Merged Ozone Data Set)

Detailed intercomparisons of monthly zonal mean total column ozone measurements from OMI-TOMSV8, OMI-DOAS, and Merged Ozone Data Set (MOD Rev2) were conducted for the period October 2004 through December 2005. (The MOD data set for this time period consists only of NOAA-16 SBUV/2 with MOD offset of -1.1 DU applied to all latitudes.) The agreement between OMI-TOMSV8 and MOD has been generally within 2 DU. For OMI-DOAS, the results confirmed that the upcoming version 1.01 will show better agreement with both OMI-TOMSV8 and MOD compared to the provisional released version 0.942.The year-to-year changes were examined through differences between Oct-Dec 2004 and Oct-Dec 2005. Our analyses indicated that the agreement among the three data sets in this respect demonstrated agreement in sign and in magnitude to within 1-2 DU. Comparisons of OMI-DOAS(V0.942) and OMI-DOAS(V1.01) were investigated using the weekly zonal means extracted from the 8-week period (March 19, 2006 - May 13, 2006). Discussions will include the effects of various data screening procedures based on the following parameters specified by OMI total ozone products: (i) the 331 nm reflectivity, (ii) the quality flags, and (iii) the column ozone precision.

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Title: Aircraft Laser IR Absorption Spectrometer (ALIAS) Measurements of total water, total water isotopes, and tracer gases N2O, CH4, and CO

The Aircraft Laser IR Absorption Spectrometer (ALIAS) measures, in situ, total water and its isotope ratios, especially in and out of cirrus, and tracers CO, CH4, and N2O. ALIAS pioneers the use of

novel miniature semiconductor lasers and is the first atmospheric instrument to employ quantum-cascade lasers and interband-cascade lasers. Automated isokinetic sampling, low wall-loss from its 900 W heated inlet probe, exceptionally high flow rate (12 liters s-1) through an isothermal (15 ºC) sample cell, provide quick sampling (1.3 s) and high sensitivity. ALIAS records both direct and harmonic absorption spectra and has reported total water measurements at unprecedented precision (40 ppbv) and range (0.1 to 200,000 ppmv). We will report on total water and water isotope ratio measurements as well as CO, CH4, and N2O measurements made during Pre-AVE, WIIM, and CR-AVE including validation activities for Aura from the upper troposphere down to pressure altitudes of 750 mbar allowing the first validation of Aura-TES global water isotope mapping.

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Title: Validation of the TES Spectral Radiances and the TES Forward Model: Implications for Retrieval Error

The accuracy of the TES retrieval products is a direct function of the accuracies of the TES spectral radiances and the forward model. The retrieval of atmospheric information from remotely sensed radiances, most particularly for tropospheric ozone, is a poorly posed problem. Systematic error in the measured and forward model spectral radiances can have a significant impact on retrieval accuracy. It is the evaluation and mitigation of this error that is the focus of this presentation. To evaluate the TES spectral radiance error, direct comparisons have been made with measurements obtained with the University of Wisconsin S-HIS spectral radiometer flying under TES on the ER-2 as part of the AVE campaign and with radiances obtained from the AIRS instrument 15 minutes prior to those from TES. With respect to the forward model, progress was made toward the goal of achieving temperature retrievals that are as accurate as possible for atmospheric species retrievals (i.e. H2O, O3, CO). Since the TES temperature retrieval utilizes species in different spectral regions, spectroscopic consistency is required: (i) for each band; (ii) for all bands of a given species (e.g. CO2 v2 and v3); (ii) for all species for a given observation (carbon dioxide, water vapor and ozone); and (iii) between observations from multiple instruments that use different spectral regions and techniques (e.g. AIRS, TES and ACE).

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Title: Intercomparison of a variety of Aura and airborne ozone observations during PAVE

Ozone observations from Aura and other satellite instruments are compared with coincident observations from airborne instruments during the Polar Aura Validation Experiment in January and February 2005.

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Title: Chlorofluorocarbon (CFC) observations by HIRDLS

Global HIRDLS observations of CFC 11 and CFC 12 are presented.

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Title: Intercomparison of trace gas observations by Aura instruments with observations by an airborne infrared spectrometer

Observations of H2O, HCl, HNO3, CO and N2O by Aura instruments are compared with coincident observations by an airborne Fourier transform spectrometer during the Polar Aura Validation Experiment (PAVE) in January and February 2005.

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Title: Noncoincident Validation of Aura MLS Observations Using the Langley Research Center Lagrangian Chemistry and Transport Model

We use the LaRC Lagrangian Chemistry and Transport Model [Pierce et al., 2003; Pierce et al., 1999] to evaluate Aura MLS observations. The LCTM calculates the transport, mixing, and photochemical evolution of an ensemble of parcels that have been initialized from HALOE and ACE-FTS occultation measurements. In this version of the LCTM, model trajectories are calculated using analyzed winds from the NASA Global Modeling and Assimilation Office GEOS-4 data assimilation system, and overhead column ozone is calculated from PV-mapped MLS ozone fields. We focus on the late November, 2004 time period due to the relatively large amount of HALOE observations made during that month. We first provide an overview of the model formulation and compare pv-mapped and bin-averaged total ozone from MLS Aura MLS observations. We then compare HALOE-initialized model predictions of O3, HCl, CH4 and H2O to subsequent HALOE observations to determine the accuracy and precision of the model predictions. Finally, we compare model output to MLS observations. Preliminary results suggest MLS observations agree well with HALOE-initialized LCTM output during this time period.

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Title: MicroMaps CO Measurements over North America during July 2004

The MicroMAPS instrument is a nadir-viewing, gas filter-correlated radiometer which operates in the 4.67 micrometer fundamental band of carbon monoxide. Originally designed and built for a space mission, this CO remote sensor is being flown in support of satellite validation and science instrument demonstrations for potential UAV applications. The MicroMAPS CO instrument was flown for the first time during the Summer-Fall 2004 on-board the Proteus aircraft, which is owned and operated by Scaled Composites. The instrument system, flown on Proteus, was designed by an Aerospace

Engineering student team as a senior design project at Virginia Tech, in Blacksburg, VA. This proposed design was reviewed and revised by Systems Engineers at NASA Langley; the final instrument system was integrated and tested at NASA LaRC in partnership with Scaled Composites and Virginia Space Grant Consortium, which supervised the fabrication of the nacelle which houses the instrument system on the right rear tail boom of Proteus. Full system integration and flight testing was performed at Scaled Composites, in Mojave, in June 2004. Its successful performance enabled participation in three international science missions: INTEX -NA over eastern North America in July 2004, ADRIEX over the Mediterranean region and EAQUATE over the United Kingdom region in September 2004, piggy-backing with the IPO-sponsored payload flown on Proteus. These flights resulted in nearly 100 hours of science measurements and in-flight calibrations.

In parallel with the engineering developments, theoretical radiative transfer models were developed specifically for the MicroMAPS instrument system at the University of Virginia, Aerospace and Mechanical Engineering Department by a combined undergraduate and graduate student team. With techical support from Resonance Ltd. In June 2005, in Barrie, Canada, the MicroMAPS instrument was calibrated for the conditions under which the Summer-Fall 2004 flights occurred. The analyses of the calibration data, combined with the theoretical radiative transfer models, provide the first data reduction for these science flights. These CO measurements and comparisons with CO data from the NASA DC-8, coincident MOZAIC data flights and AIRS CO retrievals will be presented.

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Title: A summary of HIRDLS Operation, Commanding and Trending from the IOT.

A historical summary of HIRDLS operation, commanding and telemetry trending is given by the IOT. Details of the health of the instrument are discussed and what indications there may be in any long term trends in instrument function, in particular how remarkably stable many critical parts of the instrument have been. The commanding history and continuing needs for commanding are reviewed and the communication and coordination between the split IOT (UCB and Oxford), the FOT and the science team are presented. Some of the tools that are used by the IOT are summarised together with the plans for the future.

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Title: Status of EOS MLS Ground Data System

This presentation provides status of the EOS MLS SIPS and SCF. It will provide highlights of the standard MLS data products, data formats, data parameters, and data support.

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Title: Comparisons Between Nitric Acid Measurements from the DC-8 and Nitric Acid Retrievals from MLS and TES during PAVE and INTEX B

We present in situ measurements of nitric acid made by the mist chamber/ion chromatography technique onboard the DC-8 and compare them to mixing ratios retrieved by two of the sensors flying on Aura. Attention is restricted to selected portions of individual DC-8 missions during PAVE (January-February, 2005) and INTEX B (February – May, 2006) where the aircraft flight track was aligned with the ground track of MLS or TES limb scans. Previous comparisons to MLS V1.5 retrievals during PAVE were mixed, showing close agreement on some flights and large discrepancies on others. We compare in situ measurements to both V1.5 and the newly released V2 retrievals from MLS for selected flights from both campaigns. Likewise, TES limb retrievals of HNO3 extending into the troposphere, from several days during PAVE and INTEX B, are compared to in situ observations along the ground track.

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Title: The Global Modeling Initiative “Combo” CTM – Applications to analysis of Aura data

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Title: A Global Modeling Initiative Study of the Long-Range Cross-Tropopause Transport of Biomass Burning Pollution using Carbon Monoxide Measurements from AURA

Recently, we identified a stratospheric tape recorder in carbon monoxide (CO), a seasonal oscillation in tropical lower stratospheric concentrations, in the Aura Microwave Limb Sounder (MLS) data. We found that the CO tape recorder is linked to seasonal biomass burning, closely following the two maxima in tropical burning which occur around March and September of each year. This CO is often lofted by convection to the upper troposphere as fires are typically set preceding the arrival of seasonal rains to clear agricultural fields and pastures. We will 1) present Aura MLS data in the UT/LS region, 2) discuss the locations and seasonal variations of troposphere-to-stratosphere transport of CO and highlight the transport pathways of CO in the lower stratosphere as deduced with the Global Modeling Initiative combined stratosphere-troposphere CTM, and 3) explore the impact on the lower stratosphere of the 1997 Indonesian fires, one of the largest wildfires of the 20th century.

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Title: Comparisons of TES retrieved cloud products

TES retrieves cloud top pressure and effective cloud optical depth simultaneously with the trace gas retrievals. This presentation will show comparisons of TES clouds products with AIRS and MODIS cloud products based on v002 data. I will also discuss trace gas comparisons as a function of effective cloud optical depth.

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Title: Surface and TOA Cloud Forcing from MLS IWC Product

Cloud forcing, which describes the net change in longwave (5-100 um) and shortwave (0.2-5 um) radiative flux at the surface or top-of-atmosphere as a result of the presence of any form of clouds, is a key feature in understanding several climate feedback mechanisms which contribute substantially to the disagreement between model results. A great source of uncertainty in cloud forcing arises from the presence of multiple overlapping cumulus and cirrus clouds. One method for elucidating the differential contribution to the total forcing between various cloud overlap schemes is to compare measured surface and TOA cloud forcing to independent cloud layer measurements. Since the Ice Water Content product from the Aura Microwave Limb Sounder provides a vertical description of ice clouds from 316 hPa and above, we can potentially use this product to understand the forcing of high-level clouds.

We have used the IWC product to calculate TOA cloud forcing with two fast radiative transfer models and compared the results to the CERES ES-4 product in the longwave and shortwave. This work suggests that an overestimate of the cloud forcing as compared to CERES measurements even though we have not considered clouds below 316 hPa in the intercomparison. Additionally, we compared the cloud forcing derived from the European Centre for Medium Range Weather Forecasting analysis data and found that the cloud forcing calculated from their IWC product generally agrees with CERES measurements in the tropics. These results suggest that the MLS IWC product may be overestimated and we propose several IWC calibration adjustments.

The development of an appropriate cloud forcing intercomparison methodology is far from complete. The temporal and spatial averaging of cloud forcing values do not generally correspond to the cloud forcing from the temporal and spatial averaging of the inputs to a radiative transfer model. In particular, the calculation of shortwave cloud forcing for partially filled grid boxes is quite challenging, and we propose some methods for addressing these challenges.

Finally, we have performed some preliminary analysis of surface cloud forcing calculations using the Baseline Surface Radiation Network and have found that these data, though spatially sparse, are well-calibrated and can be used to validate many of the assumptions in our cloud forcing calculations.

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Title: Using Satellite Measurements from OMI and other Aura instruments to Investigate a Regional-Scale Pollution Episode

Even though nearly 90% of the total column comes from ozone in the stratosphere, total ozone measurements from satellites contain information about both the troposphere and the stratosphere. In this study, we attempt to take advantage of the daily complete global sampling availability of OMI to see if tropospheric information on a regional scale can be obtained using OMI total ozone measurements. To isolate how much ozone is in the stratosphere, we use calculations from NOAA's Global Forecast System (GFS) model that calculates a daily ozone distribution between 100 hPa and 10 hPa to derive the stratospheric column ozone (SCO) amounts and subtract that quantity from the OMI level-2 total ozone amounts to compute the tropospheric ozone residual (TOR). We focus on a period in late June 2005 when a widespread ozone pollution episode enveloped the Houston metropolitan area as well as a large region in southeast Texas. Since there is relatively little spatial variability in the SCO field, the TOR distribution should reflect the gradients in the total ozone distributions over those days. The resultant daily TOR fields are compared with (four) available ozonesonde measurements and with surface measurements that are part of the Texas air quality

monitoring network. As the ozone episode evolves, both the ozonesonde and TOR measurements capture higher amounts during the most intense phase of the episode. Additional NO2 column measurements from OMI and CO measurements from MOPITT for June 22 also show enhanced concentrations of these species for June 22, the peak day of the surface episode. Because of the day-to-day variation of the OMI pixel size over the specific region of study, some of the daily TOR distributions are not useful for regional analysis. Collectively, this set of satellite observations represents one of the first attempts to use such measurements to characterize a regional air pollution episode and provides some guidance into what additional information is desirable for such a use as well as illustrating the shortcomings that arise with the current observational capability.

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Title: HOCl from EOS MLS on Aura: Version 1.5 and preliminary version 2 data comparisons with other measurements and models

We discuss comparisons between Earth Observing System (EOS) Microwave Limb Sounder (MLS) profiles of upper stratospheric HOCl and HOCl measurements from balloon. The current MLS HOCl products (version 1.5 as well as sample preliminary version 2 data) have significant artifacts below 7 to 10 hPa; we will discuss other approaches (and possibly early results) that may provide improvements to this MLS product. Model profile results will also be presented, as well as a preliminary comparison to ENVISAT MIPAS results.

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Title: HCl from EOS MLS on Aura: version 1.5 and preliminary version 2 data comparisons with satellite, balloon, and aircraft data

We discuss comparisons between Earth Observing System (EOS) Microwave Limb Sounder (MLS) profiles of stratospheric and lower mesospheric HCl and other HCl measurements from satellite, balloon, and aircraft, with a focus on the newer versions of the MLS data (changes made from versions 1.51 to 1.52 and a preliminary version 2). We plan to present updated comparisons from a small subset of days, using the newest MLS data version.

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Title: Stratospheric ozone from EOS MLS on Aura: version 1.5 and preliminary version 2 data comparisons with satellite, balloon, and aircraft data

We discuss comparisons between Earth Observing System (EOS) Microwave Limb Sounder (MLS) profiles of stratospheric ozone and other ozone measurements from satellite, balloon, and aircraft. We also present ozone column comparisons. We discuss the modifications made for a preliminary version 2 MLS dataset, and how this changes (a small subset of) the comparisons produced to date.

In particular, this appears to improve some of the small sloping differences versus height that were evident in the version 1.5 MLS data comparisons. We also plan to present the changes that occur in MLS mesospheric ozone, from the preliminary version 2 data.

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Title: HCl from EOS MLS on Aura: version 1.5 and preliminary version 2 data comparisons with satellite, balloon, and aircraft data

We discuss comparisons between Earth Observing System (EOS) Microwave Limb Sounder (MLS) profiles of stratospheric and lower mesospheric HCl and other HCl measurements from satellite, balloon, and aircraft, with a focus on the newer versions of the MLS data (changes made from versions 1.51 to 1.52 and a preliminary version 2). We plan to present updated comparisons from a small subset of days, using the newest MLS data version.

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Title: The role of Asian monsoon/Tibet convection in stratosphere hydration and creating “tape recorder” signal

Although the Asian monsoon/Tibet region is a primary center of lower stratosphere hydration, it remains unclear whether water vapor enters the lower stratosphere in this region would contribute significantly to change of water vapor in the middle stratosphere, as represented by the “tape recorder” signal (Mote et al. 1996). Recent numerical model simulations have suggested that at least 25% of the moist signal in the “tape recorder” may be contributed by the Asian monsoon (Bannister et al. 2004). However, considerable uncertainty may exist because of substantial differences between the lower stratosphere moist center in these numerical simulations and that observed by satellites. Our analysis of Aura MLS suggests a clear “tape recorder” signal in Asian monsoon/Tibet region. We will present results of trajectory analysis begins with the higher water vapor measurements at 100 hPa by Aura MLS for the summer of 2004, 2005 to assess the cause of this “tape recorder” signal and its relation with the global tropical “tape recorder” signal.

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Title: Characteristics and Validation of HIRDLS Water Vapor Retrievals

HIRDLS water vapor distributions are retrieved from the radiances in Channels 18 and 20. These are 2 of the channels least impaired by the plastic blockage in the optical train, and so should be in a favorable position on the focal plane to give good results. However, the radiances in these channels

are low, and the channels are strongly affected by temporal variations in the signal from the blockage. We present the present (V2.00 and variants) water vapor retrievals and discuss the characteristics of their indicated vertical and latitudinal variations. We then present results of comparisons to water vapor sondes, A/C measurements, MLS and other satellites, where possible.

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Title: Ice supersaturation and its impact on chemistry and climate

Ice processes are critical for understanding cirrus clouds, which impacts both the radiation balance of the climate system and the chemistry and hydrologic cycle of the upper troposphere and lower stratosphere. Observations of atmospheric humidity from a variety of recent observations indicate that supersaturated regions may be large enough to be seen from satellites, and relevant for the scales of global models. Global observations of ice supersaturation from the Atmospheric Infrared Sounder (AIRS) and both UARS and Aura Microwave Limb Sounders (MLS) are discussed and a climatology of ice supersaturation is presented. The impact of ice supersaturation on climate and chemistry of the stratosphere and troposphere is examined with results from a coupled chemistry climate model.

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Title: First Results of the OMI Ozone Profile

From the UV wavelengths between 270-330 nm in the OMI spectrum, information is available on the ozone profile. Such profiles can be retrieved for each OMI ground pixel in the UV1, resulting in a spatial resolution of 13x48 km at nadir. Although the vertical resolution is limited, the OMI ozone profiles provide a unique three-dimensional view on ozone.

A new algorithm has been developed to retrieve ozone profiles from OMI reflectance measurements. The algorithm is based on optimal estimation and uses an iterative inversion approach starting from an a-priori profile taken from a climatology. On-line radiative transfer calculations are performed taking into ccount clouds, Ring effect and polarization. Cloud pressure and fraction are taken from the OMI O2-O2 cloud product.

The product provides the ozone profile for 18 layers, averaging kernel, the degrees of freedom of the signal, the error covariance matrix, and other diagnostic information. The code usually converges in 4 iteration steps.

First results of the OMI ozone profile algorithm will be presented, as well comparisons with ozone sondes and MLS profiles.

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Title: Validation Status Report: Carbon Monoxide from MLS in the middle atmosphere.

We asses the quality of the middle-atmosphere carbon monoxide product from MLS by comparing it to other remotely sensed measurements, from ACE-FTS and ODIN-SMR. We also assess whether

the observed distribution is consistent with the observed winds. We examine both the released version 1.5x data and the version 2 data which are currently being developed. Data from all three instruments are qualitatively similar. The MLS data show some unrealistic features in V1.5x which are reduced significantly in version 2.

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Title: A tape recorder signal in EOS MLS HCN.

The signal from HCN detected by MLS is not strong. If a weekly zonal mean of the radiances is constructed, however, the signal is clear enough for a weekly zonal mean of mixing ratio to be retrieved. In the lower stratosphere, the quality of the data increases from being essentially useless at 100mb to being of clearly acceptable quality at 10mb and higher. If time mean is subtracted, and a time series of the resulting anomaly is plotted for the equator, we observe layers of low-HCN and high-HCN air rising from the tropical tropopause into the tropical lower stratosphere. Such an effect has been observed before, in water vapour and CO, and has been named the “tape recorder” effect. The HCN tape recorder is different in that it does not repeat annually. The data available so far suggest that if the signal does repeat regularly, it does so on a two-year timescale.

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Title: HIRDLS Aura Spacecraft Pitch Maneuvers - Rationale, Planning and Execution.

This paper describes the background to the Aura pitch maneuvers that are used for HIRDLS in-flight characterisation for radiometric correction analysis. The original conception for in-flight calibration is mentioned and the rationale and requirements for the current implementation of the maneuvers is presented. A brief description of the planning, the execution of the maneuvers and the utilization of HIRDLS during them is presented. Some mention is made of the type of analysis of HIRDLS science data that is uniquely afforded by the pitch down of the spacecraft.

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Title: NO2 observations from a small spectrometer using the direct sun technique

Very precise NO2 data have been retrieved at Thessaloniki, Greece using a small spectrometer observing the solar disk from 270 to 510 nm with a resolution of 0.5 nm and a step size of 0.2 nm. We observed from 13 July 2006 to 25 July 2006. The retrievals show excellent match to optical depths calculated from laboratory NO2 absorptions cross sections without requiring shift and squeeze techniques. The results show a diurnal variation of total column NO2 for each day of observations with data obtained every 3 minutes. Typical values in Thessaloniki during July ranged from 0.5 to 1.5 DU

of NO2. In addition to NO2, we simultaneously retrieved aerosol optical depth, angstrom coefficient, and water vapor total column.

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Title: TES comparisons of water vapor with aircraft, AIRS and sondes

The new version 2 TES water vapor retrievals at the DAAC have been evaluated by comparison with measurements located close in time and space. The validation data sources include DC-8 and WB-57F aircraft in-situ water measurements from INTEX, AVE, and CR-AVE missions, AIRS, and sondes. The mean bias and rms error of TES water relative to these other measurements will be explored.

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Title: Comparisons of TES temperature profiles with aircraft, AIRS and sondes

The new version 2 TES temperature retrievals have been evaluated by comparison with measurements located close in time and space. The validation data sources include DC-8 and WB-57F aircraft temperature measurements from INTEX, AVE, and CR-AVE missions, AIRS, and sondes (including Ticosonde). The mean bias and rms error of TES temperature relative to these other measurements will be explored.

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Title: Tropospheric and Stratospheric Water Measurements from the JPL Laser Hygrometer

The JPL Laser Hygrometer (JLH) measures in-situ water vapor from the WB-57F aircraft platform. In support of Aura, this instrument has provided measurements during the Aura Validation Experiment (AVE) in 2004 and 2005, the Water Isotope Intercomparison Mission in July 2005, and Costa Rica AVE in January-February 2006. A summary of the measurements and recent findings relevant to Aura validation will be presented.

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Title: Intercomparisons of OMI and MODIS Deep Blue Aerosol Products

As part of the so-called A-Train satellite constellation, Aqua and Aura are deliberately placed to take

synergistic measurements to help provide a better understanding of climate forcing due to trace gases, aerosols and clouds. The major research objective of this project is to intercompare aerosol products for OMI and MODIS to assure that the data quality of the satellite measurements meets the necessary requirements for climate data records.

Although there have been extensive studies using satellite data of aerosols over ocean, the aerosol information over land are still incomplete. Such retrievals over land have been difficult to perform using previously available algorithms that use wavelengths from the mid-visible to the near IR because they have trouble separating the aerosol signal from the contribution due to the bright surface reflectance. Therefore, only few satellite sensors, such as OMI and MISR, provide aerosol retrievals over land, including bright-reflecting surfaces. Recently, as a result of the newly funded project in the 2004 EOS re-competition, aerosol information from MODIS over bright surfaces such as desert, semi-desert, and urban regions will soon be added to the suite of MODIS operational products using our Deep Blue algorithm. The Deep Blue algorithm uses 412, 470, and 670 nm channels from MODIS. Therefore, both MODIS Deep Blue and OMI algorithms are using the blue part of spectrum, allowing for straightforward intercomparisons and synergy between these two sensors.

In this paper, we will show the results of intercomparisons of aerosol optical thickness between MODIS Deep Blue and OMI on a global basis. Monthly statistics of correlation and histogram of aerosol optical thickness between these two sensors will be generated and contrasted. Also, to characterize the differences due to artifacts in the aerosol retrievals (such as cloud contamination, aerosol height, and aerosol model assumption, etc.), the bias and scatter in these comparisons will be addressed separately for each individual region that contains different dominant types of aerosols and different meteorological environments. We will also compare the determination of aerosol type, dust or smoke, using both the visible aerosol index from the OMI near-UV aerosol algorithm and the Ångström exponent values from the MODIS Deep Blue algorithm. These results will help scientists using OMI data better trace possible sources of excess tropospheric ozone for studies of photochemistry.

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Title: Water vapor transport in the UT/LS over the Tibetan Plateau/South Asian Monsoon region

Data from the Microwave Limb Sounder on the Aura and the outputs from the Goddard fast trajectory model are used to examine transport pathways of water vapor in the upper troposphere/lower stratosphere over the Tibetan/South Asian monsoon region. The results confirm the 'Short-circuit' transport of water vapor to the global stratosphere by convective activities over the Tibetan Plateau during boreal summer, and highlight the fast, quasi-horizontal transport between low and mid latitudes in the lower stratosphere.

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Title: Formation of Large (50-100 micron) Ice Crystals Near the Tropical Tropopause: Implications for Water Vapor Concentrations

Recent high-altitude aircraft measurements with in situ imaging instruments indicated the presence of relatively large (50-100 micron diameter), roughly equidimensional ice crystals near the tropical

tropopause in very low concentrations (< 1/L). Growth-sedimentation calculations indicate that regardless of assumptions about temperature profile, deposition coefficient, ice nucleation threshold, ice phase or crystal habit, existence of the observed crystals is only possible if the tropopause layer was highly supersaturated (relative humidities with respect to ice approaching 200%). In addition, either very slow or selective ice nucleation must have occurred such that these large supersaturations could be sustained in the clouds. The existence of these large crystals provides a robust constraint on the water vapor concentration in the tropopause region. The inferred minimum water vapor concentration (about 4 ppmv) required to grow these crystals is consistent with the airborne Harvard Lyman-alpha water vapor measurements, but inconsistent with the balloon-borne Frostpoint hygrometer measurements. Comparisons between the water vapor concentrations inferred from crystal growth calculations and Aura measurements will be presented.

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Title: Cross-Comparison of Aura MLS and Aqua AIRS cloud measurements

The near-simultaneous measurements of clouds by the Aura-MLS and Aqua-AIRS on the A-Train framework provide a unique opportunity to cross-examine the cloud products from these two instruments with a large number of coincident measurements. We compare the collocated and coincident cloud measurements between Aura-MLS and Aqua-AIRS and found an overall good agreement in the spatial distribution (morphology) of upper tropospheric clouds as measured by the MLS and AIRS. Some differences between MLS and AIRS can be generally understood as caused by the differences in retrieval method and sensitivity limit of two instruments.

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Title: EOS MLS Upper Tropospheric and Lower Stratospheric Ozone Validation by Sonde Measurements

We present validation studies of upper tropospheric and lower stratospheric ozone profiles from the Earth Observing System Microwave Limb Sounder (MLS) instrument on the Aura satellite. Ozonesonde measurements from over 30 sites worldwide are compared with coincident MLS data. The version 1.5 MLS ozone stratospheric data agree well with sonde measurements (typically within 10-20%, and within 5-10% for a global average). MLS upper tropospheric tropical data are biased high versus the sondes. We also show ozone partial column comparisons. We will discuss the changes made in a preliminary version 2 MLS dataset, and how this changes (a subset of) the comparisons with ozonesonde data.

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Title: Summertime tropospheric ozone columns from Aura OMI/MLS measurements versus regional model results over the United States

The tropospheric ozone residual method is used to derive tropospheric column ozone (TCO) for the summer of 2005 based on the stratospheric ozone columns from Microwave Limb Sounder (MLS) measurements and the total ozone columns from the Ozone Monitoring Instrument (OMI) measurements on the NASA Aura satellite. The tropospheric columns are compared with concurrent ozonesonde measurements over the US and are shown to be in good agreement. The distributions of the OMI/MLS TCO are found to be generally consistent with the Regional Air Quality Forecast model results over the US and its surrounding oceans in summer 2005. Both model simulations and OMI/MLS TCOs show high tropospheric column ozone over the southeastern US and western Atlantic. They also show similar decreases in TCO over the southeastern US and the Gulf of Mexico from June 17-31 to July 1-17, 2005. The changes are indicated to be associated with near-surface ozone changes and geopotential height changes at 147 hPa.

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Title: Validation of OMI Cloud Pressure from rotational Raman scattering using aircraft and satellite data with emphasis on ozone retrievals

We compare the OMI cloud pressure product using rotational Raman scattering (OMCLDRR) qualitatively with lidar data from several INTEX-B flights as well as with Aqua MODIS cloud pressures derived from cloud-slicing and infrared window brightness temperatures. We focus on several different scenarios: 1) clouds observed in the presence of absorbing aerosol 2) multi-layer cloud decks 3) single-level cirrus 4) single-level low-lying water clouds. We find that absorbing aerosol can cause the algorithm to retrieve cloud pressures that are too low. In the presence of multiple cloud decks, the algorithm retrieves higher pressures than those at the top of the upper deck (to which the MODIS cloud-slicing technique is sensitive). Radiative transfer calculations have been performed to simulate these effects. In addition, we will show how the use of these cloud pressures affects the OMI TOMS v8 (OMTO3) ozone retrievals on a daily and monthly basis as compared with the climatological cloud pressures that are currently used in the algorithm.

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Title: Analysis of the Impact of Biomass Burning on Tropospheric Ozone Using Assimilated TES Observations and Complementary Satellite Data

Observations of tropospheric O3 and CO from the TES instrument for November 2004 are analyzed using a chemical data assimilation system. The TES data reveal significantly high concentrations of tropospheric O3 and CO in the southern hemisphere. These enhanced abundances of O3 and CO are not reproduced by the GEOS-Chem global chemical transport model, and reflect the influence of extensive biomass burning in parts of Australia, Indonesia, and southern Africa. We examine the impact of emissions of CO and NOx from these fires on the distribution of tropospheric O3. Observations from TES, MOPITT, and SCIAMACHY are assimilated using a Kalman filter approach in the GEOS-Chem model. The assimilation improves significantly the modeled O3 and CO abundances in the southern hemisphere. We show that accurately accounting for the NOx emissions, as reflected

in the SCIAMACHY observations of NO2, is critical for reproducing the observed O3 in the assimilation system.

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Title: Developing a Climatology of Stratospheric Injections from Boreal Forest Fires

An increase in boreal fire activity and severity has been observed since the 1950s, and further increases due to climate change are expected. Recent remote sensing and in situ observations show that highly polluted, smoke-laden air from these fires can be injected into the upper troposphere and even the stratosphere, where it can remain for weeks. Only limited data exists on the current frequency of these injection events and the mass deposited into the stratosphere; the impacts on this region of the atmosphere have not been assessed.

We are using data sets from Aura and Aqua to locate and track these injection events and develop a broader perspective of their frequency, magnitude, and mechanism. OMI and TOMS aerosol index measurements has been used as a primary filter to identify times and locations where particles are lofted high into the atmosphere, indicating possible pyrocumulus activity. Seasons and geographic regions showing enhanced frequency of such events will be identified, and confirmation of these events as fire plumes will rely on CO measurements from TES and MODIS fire products.

Aura's capability to measure ozone in the lower stratosphere where trends have a large uncertainty and have not been explained, coupled with the considerable chemical information provided by TES (and also MLS and OMI for specific gases), will allow us to investigate the chemical nature of these smoke injections and thereby make a preliminary assessment of the possible effects on tropospheric and possibly stratospheric ozone.

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Title: TES observations of the North American pollution outflow in summer 2006

During summer 2006, TES will observe a large number of ozone, carbon monoxide and water vapor latitudinal cross sections over the northern midlatitudes between 130W to 15E. We will present a preliminary interpretation of these measurements in terms of pollution transport from North America to Europe using correlative meteorological and chemical data as well as a global chemistry transport model (GEOS-Chem). The impact of lightning occurring over the southeastern United States to the North American outflow will also be investigated.

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Title: Aura validation of numerous molecules using FIRS-2 balloon observations

FIRS-2 has obtained validation observations for Aura (especially for MLS) for a number of molecules on the balloon flights on September 23/24 2004 and September 20/21 2005 from Fort Sumner, NM. The list of molecules that have direct relevance to Aura include O3, HCl, HOCl, ClNO3, OH, HO2,

H2O2, N2O, HNO3, CFC11, CFC12, H2O, and HDO. I will show validation analyses of Aura data using these FIRS-2 data, and include appropriate data from other instruments on the same balloon gondola, including BOH, MkIV, and SLS. Most of the above molecules are measured by more than one of the balloon instruments. I will concentrate on the molecules that are not covered by other presenters during the meeting.

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Title: A-Train Data Depot: Integrating and Visualizing Atmospheric Measurements Along the A-Train Tracks

The succession of US and international satellites that follow each other, seconds to minutes apart, across the local afternoon equator crossing is called the A-Train. The A-Train consists of the following satellites, in order of equator crossing: OCO, EOS Aqua, CloudSat, CALIPSO, PARASOL, and EOS Aura. Flying in such formation increases the number of observations, validates observations, and enables coordination between science observations, resulting in a more complete "virtual science platform". (Kelly, 2003) The goal of this project is to create the first ever A-Train virtual data portal/center, the A-Train Data Depot, to process, archive, access, visualize, analyze and correlate distributed atmosphere measurements from various A-Train instruments along A-Train tracks. The A-Train Data Depot (ATDD) will enable the free movement of remotely located A-Train data so that they are combined to create a consolidated vertical view of the Earth's Atmosphere along the A-Train tracks. Once the infrastructure of the ATDD is in place, it will be easily evolved to serve data from all A-Train data measurements: 'one stop shopping'. The innovative approach of analyzing and visualizing atmospheric profiles along the platforms track (i.e., time) will be accommodated by reusing the GSFC Atmospheric Composition Data and Information Services Center (ACDISC) visualization and analysis tool, GIOVANNI, existing data reduction tools, on-line archiving for fast data access, and Cooperative Institute for Research in the Atmosphere (CIRA) data co-registration tools. Initial measurements utilized include CALIPSO lidar backscatter, CloudSat radar reflectivity, clear air relative humidity, water vapor and temperature from AIRS, and cloud properties and aerosols from both MODIS. This will be followed by associated measurements from MLS, OMI, HIRDLS, and TES. Given the independent nature of instrument/platform development, the ATDD project has been met with many interesting challenges that, once resolved, will provide a much greater understanding of the relative flight dynamics and data co-registration of the suite of A-Train instruments, thus greatly increasing the accuracy of A-Train data analysis. Some of these challenges will be discussed. The project's resulting visualizations and analysis illustrate the importance of managing data so that measurements from various missions can be combined to enhance the understanding of the atmosphere. A-Train data management coordination, as performed here, is extremely significant in facilitating the A-Train science of clouds, precipitation, aerosol and chemistry.

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Title: High Resolution Dynamics Limb Sounder (HIRDLS) Meteorological Products Current Use and Future Needs

An update will be given on behalf of the HIRDLS Science Team on our usage of GMAO

meteorological products. Examples on how these data products are used for algorithm development, operational retrievals, and validation will be highlighted. Issues (if any) regarding delivery of current GMAO GEOS-4 and future GMAO GEOS-5 meteorological products to HIRDLS SIPS will be discussed.

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Title: Status of the High Resolution Dynamics Limb Sounder (HIRDLS) HNO3 Data Product

This presentation updates the status of the HIRDLS HNO3 data product. The general morphology of HNO3 will be discussed. Validation of HNO3 with satellite correlative data from the Aura Microwave Limb Sounder (MLS), Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), and Atmospheric Chemistry Experiment (ACE) instruments will be shown. Coincident comparisons in the UTLS region will also be shown with correlative data obtained from available NASA aircraft campaigns (e.g., 2005 Houston AVE and 2006 CRAVE).

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Title: MLSgrid: Development of a System for more Efficient Data Processing

The EOS Microwave Limb Sounder (MLS) instrument produces over 9GB a day of both raw and processed atmospheric chemistry data. The MLS Science Computing Facility (SCF) houses resources that science team members use to analyze this data, specifically for performing tasks related to algorithm development, testing data processing configurations, analyzing instrument and science data, and conducting validation studies. While the SCF\u2019s resources are adequate to perform science team members\u2019 tasks, there has been an on-going problem managing these resources to perform optimally. Sun Grid Engine (SGE) is a piece of open-source software that is currently being implemented at the SCF to help the facility better manage its resources and increase science team output by creating a grid network. With this grid technology, the SCF can become a more productive computing center for the geographically separated MLS science team members and their associated computing resources. This grid network, built with SGE, would make sure that all SCF data processing needs are met. This poster will give a status of where the development is at, how it performs, and what future work needs to be completed.

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Title: The New MLS Web User Interface

Two Microwave Limb Sounder (MLS) instruments have provided the scientific community with atmospheric data for over a decade. As part of an effort to analyze, validate, and publish results, the

MLS public website has recently been re-engineered to better accommodate the needs of MLS data users. Data users are now able to register to receive MLS updates and discuss collaborations with the MLS science team. Additionally, tools such as data processing and instrument status calendars, daily and weekly data plots, scientific documentation, information on specific research topics, and lists of publications have recently been made available through this website to help data users familiarize themselves with MLS data products. This talk will introduce the Aura science community to the new MLS website and the data user tools available there.

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Title: Ozone loss by the HOCl catalytic cycle: do models have it right?

The HOCl catalytic cycle for ozone loss is important in the mid-latitude stratosphere. We use a diurnal steady-state photochemical model to calculate profiles of HOCl for conditions sampled by two high-altitude balloon-borne instruments, MkIV and FIRS-2. To assess how well this model represents ozone loss by the HOCl cycle, we compare our calculations of HOCl and its precursors, ClO and HO2, with measurements obtained by an FTIR solar absorption spectrometer (MkIV), a far-infrared emission spectrometer (FIRS-2), and a submillimeterwave limb sounder (SLS). We then evaluate these comparisons in light of a number of recent laboratory studies of the main formation mechanism of HOCl, the reaction of ClO \+ HO2. Preliminary comparisons between model and observations suggest better agreement might be achieved with a faster rate constant. Presently, Aura MLS retrievals of HOCl are being conducted as a research product. Once we gain confidence in the model representation of HOCl from the balloon flights, the model will be used to evaluate the accuracy of MLS retrievals of HOCl.

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Title: Validation of MLS BrO

We discuss measurements of stratospheric BrO obtained by the Microwave Limb Sounder (MLS) on the Aura satellite. These measurements span an altitude range of 32 to 42 km. Previous measurements of stratospheric BrO profiles have sampled lower stratospheric altitudes: balloon-borne DOAS, SAOZ-BrO, and in situ instruments; aircraft-borne in situ instruments; and the satellite-borne SCIAMACHY instrument. To compare MLS measurements with those obtained lower in the stratosphere, we use a photochemical model in conjunction with the measurements to compute total inorganic bromine (Bry). Since Bry, unlike BrO, should remain approximately constant with altitude, it provides a proxy for comparison.

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Title: Comparing OMI TOMS and OMI DOAS total ozone column estimates

In this paper we report on comparing the output of the OMI DOAS and OMI TOMS total ozone column retrieval algorithms. Although both rendering total ozone column data, these algorithms differ in many aspects; the wavelength range used and wavelength resolution, the method to retrieve slant column values, the use of surface albedo and snow/ice data, and much more. Besides estimates of the total ozone column these algorithms also yield individual estimates of cloud fraction and cloud top pressure, again based on different techniques and using different assumptions. In this study we first compare global images of the total ozone columns as produced by both algorithms, to check whether they render the sam patterns and structures. Statistical analysis of one year of OMI data shows that OMI TOMS and OMI DOAS total ozone columns correlate well but are biased with respect to each other. Correlation coefficients calculated per week of data range from 0.85 to 0.99. Globally averaged, OMI-TOMS reports 4-5 DU less total ozone column than OMI-DOAS. We then look more qualitatively at how well both quantities correlate over the course of one year of data. Intriguing findings are reported on the difference between TOMS and DOAS total ozone columns in global images, as a function of various parameters describing the measurements geometry and as a function of geophysical quantities measured over the same ground pixel. The analysis reveals the presence of subtle differences between both retrieval algorithms, such as the treatment of clouds, surface albedo, land snow and sea ice, volcanoes releasing sulphur dioxide, and solar zenith angle effects.

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Title: Validation results from the joint ESA KNMI NIVR Calibration and Validation Announcement of Opportunity for the Ozone Monitoring Instrument

In this paper we wish to report on the progress achieved within the framework of the joint ESA KNMI NIVR Calibration and Validation Announcement of Opportunity for the Ozone Monitoring Instrument aboard the EOS Aura satellite (OMI-AO). Publication of the OMI-AO in May 2004 was synchronized with the NASA NRA on Aura Validation to serve the European scientific community on atmospheric research and composition with an opportunity to work with OMI data prior to its public release. We were delighted to learn that many of our respected European colleagues in the field of atmospheric research responded to the OMI-AO and that high quality contributions to the validation of OMI satellite data products were foreseen. We were also delighted to learn that a fair number of proposals originated from scientists in related fields of research and from research institutes in Eastern Europe and Russia, broadening the scope of the OMI-AO and adding a number of correlative data networks. The results that we intend to present are extracted from the half yearly progress reports as send in by the OMI-AO Principal Investigators. Hence this presentation reflects the progress achieved by the scientists in the framework of the OMI-AO.

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Title: Retrievals of nitric acid from the Tropospheric Emission Spectrometer limb viewing mode

Initial retrievals and characterization of nitric acid (HNO3) are presented using data from the Tropospheric Emission Spectrometer (TES) limb viewing mode from global surveys from Fall, 2004,

January, 2006, and Spring, 2006. Analysis of the spectral residuals indicates spectroscopic issues in the 11.2 um band and contradictory information from the Nitric Acid vs. CO2 spectroscopic regions. Comparisons to MLS results and results using the MIPAS retrieval approach applied to TES data are presented.

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Title: Global Measurements of Formaldehyde and Glyoxal from the Ozone Monitoring Instrument

The Ozone Monitoring Instrument (OMI) on EOS Aura makes routine measurements of formaldehyde (HCHO) and has recently demonstrated the capability to observe glyoxal (CHOCHO). HCHO sources include oxidation of methane and isoprene, and HCHO is therefore the major proxy for VOC emissions and an indicator for urban air quality. CHOCHO, a VOC recently detected in ground-based measurements in Mexico City, is produced from the oxidation of numerous other VOCs; compared to HCHO, it is not affected directly by vehicle emissions and has a significantly shorter life time.

OMI is in the unique position to observe both gases simultaneously, with daily global coverage and, with an equator crossing time of 1338h, at a time when VOC concentrations are close to their daily maximum.

We present the current status of HCHO and CHOCHO observations from OMI, show selected results from the last two years of measurements, and give an update on data availability and release schedule for the operational (HCHO) and off-line (CHOCHO) data product.

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Title: Global Measurements of Stratospheric Bromine Monoxide and Chlorine Dioxide from the Ozone Monitoring Instrument

The Ozone Monitoring Instrument (OMI) on EOS Aura makes routine measurements of bromine monoxide (BrO) and chlorine dioxide (OClO), both important elements in the destruction of stratospheric Ozone. While BrO can be observed globally, observations of OClO are limited to polar Spring time due to concentrations that are generally below the detection limit.

We present the current status of BrO and OClO observations from OMI, show selected results from the last two years of measurements, and give an update on data availability and release schedule for the operational data products.

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Title: A Comparison of AURA OMI Total Column Ozone (OMTO3) Data with Data from Groundstations and with Data from NOAA_16 SBUV/2

Measurements of total column ozone from the Ozone Monitoring Instrument (OMI) aboard NASA's Aura spacecraft have been systematically compared to total ozone data from numerous Brewer and

Dobson spectrophotometers worldwide. OMI data were processed with the TOMS Version 8 retrieval algorithm and compared to the ground data as a function of latitude, solar zenith angle, reflectivity and total ozone. Results show that the accuracy of the OMI retrievals is as good as or better than the retrievals from the series of Total Ozone Mapping Spectrometers (TOMS). The OMI Field of View (FOV) is 13 x 30 km at nadir and approximately 40 x 135 km at the furthest off-nadir scan position. For each day, ozone measured in a single OMI FOV most nearly co-located with the ground site is used in the comparison. The center of the OMI measurement is always located within 75 km of the station and within two hours of local noon. When multiple matches are possible, at high latitudes for instance, the OMI measurement with the shorter optical path is chosen. OMI ozone values have also been compared to column values retrieved from NOAA-16 SBUV/2. The OMI FOV is significantly smaller than that of SBUV/2 (180 x 180 km) so OMI ozone values within each SBUV/2 FOV are averaged before the comparison.
There are now over 29,500 individual matchups between OMI and the groundstations and well over 250,000 matchups with NOAA-16 for the lifetime of the OMI instrument (Oct 2004-present). This large and growing dataset permits a meaningful statistical analysis of the comparisons.

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Title: Validation of OMI products using data collected during INTEX-B

Data from the DIAL lidar system onboard the NASA DC-8 aircraft during the INTEX-B field experiment have been used to validate several OMI products such as ozone, aerosols, and cloud heights.Preliminary results show an underestimation of column ozone under conditions where cirrus clouds are present for reasons that are currently not fully understood. These aircraft data give us insight as to the errors that may be associated with some assumptions made in the standard ozone retrieval algorithms. The presence of aerosols in the lower atmosphere provides us with an opportunity to define limits on the OMI retrieval sensitivity. Various cloud top height products are being produced by OMI (O2-O2, Raman) and MODIS. The DIAL lidar data provides an excellent dataset to validate all these products. Preliminary results show that all satellite cloud products have some problems when there exist multi-layered clouds.

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Title: Validation of the Aura Microwave Limb Sounder Measurements of Stratospheric Water Vapor

We present the version 2 measurements of stratospheric water vapor from the Aura Microwave Limb Sounder and provide estimates of their precision and vertical resolution. Preliminary estimates of the accuracy of these data products will be obtained from comparisons with other instruments. Expected improvements over the previously released version (v1.5) will be discussed.

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Title: Validation of the Aura Microwave Limb Sounder Measurements of Nitrous Oxide

We present the version 2 measurements of nitrous oxide (N2O) from the Aura Microwave Limb Sounder and provide estimates of their precision and vertical resolution. Preliminary estimates of the accuracy of these data products will be obtained from comparisons with other

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Title: Ozone and Temperature comparisons of the EOS MLS and JPL ground based lidar measurements over the period September 2004 – August 2006

Updated ozone and new temperature results from the EOS MLS and the JPL ground-based lidar measurements at Table Mountain Facility, CA, and Mauna Loa Observatory, HI will be presented. The main statistical characteristics of the MLS-lidar differences will be discussed. Overall, the ozone differences remain within expected uncertainties (less than 10% throughout the stratosphere). The temperature differences remain below 2 K up to 90 km. At TMF, an additional cold bias is observed on the lidar temperatures below 30 km, allegedly due to the presence of a thin persistent aerosol layer. The malfunction of the TMF lidar Raman channel constrained us to use its Rayleigh channel instead to retrieve temperature, channel that is sensitive to Mie scattering causing a cold bias in the temperature retrieval. This bias is not observed at MLO because the Raman channel is used there below 30 km. For both ozone and temperature, a systematic 2-5 % bias which reverses at the altitude of ozone maximum, and at the stratopause seems to indicate a consistent offset between the lidar and MLS altitude/pressure registrations

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Title: Validation of HIRDLS temperature

The released version of HIRDLS temperature suggests a random error of ~ 1 K through most of the stratosphere. The assimilated temperature produced by GEOS-4 is used to check systematic biases in the HIRDLS temperature. At middle stratosphere, there is no systematic bias. However, the HIRDLS temperature shows about 5 K cold (warm) bias at 1.0 hPa (215.4 hPa) compared to GEOS-4 temperature. From 15 km and 40 km, the temperature difference between the HIRDLS temperature and GEOS-4 temperature is within 2 K. The systematic biases in the HIRDLS temperature are mainly due to systematic biases in the HIRDLS radiance, believed to result from errors in correcting for the radiance coming from the plastic film. Comparison with the temperature data from the CRAVE delivers important information for the retrieval of HIRDLS temperature.

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Title: Equatorial wave activities in HIRDLS temperature

An interesting structure suggesting equatorial wave activity is analyzed in HIRDLS temperature via an extended Kalman filter. A mode of zonal wavenumber 6 is distinct in the lower stratosphere compared with commonly used Gaussian method. When a gaussian gridding method is applied, wavenumber one or wavenumber two modes are obtained instead. The difference in the analyzed structures is attributed to the characteristic structure of the wavenumber six component. Since the information relevant to atmospheric wave structures, such as wavenumber and wave amplitude, is crucial to accurate estimation of momentum/energy transfer, the result obtained from this study would be complementary to current approaches on the momentum transfer involved with equatorial wave activities.

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Title: Validation of MLS upper tropospheric carbon monoxide

The Aura Microwave Limb Sounder observations of carbon monoxide in the upper troposphere will be discussed. Particular focus will be given to the improvements expected from the 'version 2' retrievals that are under development.

Comparisons made with in-situ aircraft data, and with observations from other satellite instruments. Potential sources of systematic errors will be identified, and plans to quantify these outlined.

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Title: Validation of MLS upper tropospheric ozone observations

Progress in the validation of the Aura Microwave Limb Sounder observations of upper tropospheric ozone will be reviewed. Comparisons will be made with correlative datasets from the various AVE campaigns and the INTEX-B mission.

Comparisons will also be made with other satellite observations. Potential sources of systematic error will be identified. This talk will focus on 'version 2' of the MLS processing, now under development. Changes between version 2 and the currently available version 1.5 will be highlighted.

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Title: Aerosol Optical Depths from Airborne Sunphotometry in INTEX-B/MILAGRO as a Validation Tool for the Ozone Monitoring Instrument (OMI) on Aura

Aerosol data products produced by the Ozone Monitoring Instrument (OMI) on the Aura satellite

include aerosol optical depth (AOD), single scattering albedo (SSA), and aerosol indices. These OMI aerosol products are derived using wavelengths and algorithms that differ significantly from those of other nadir-viewing satellite aerosol-measuring instruments, such as MODIS and MISR. These differences produce some advantages (such as aerosol retrievals over bright surfaces and clouds) and disadvantages (such as dependence on aerosol layer height) that lead to unique needs when validating and improving OMI aerosol retrievals. An example is the desire for measurements of aerosol vertical profiles in conjunction with AOD.

In March 2006 during INTEX-B/MILAGRO (Phase B of the Intercontinental Chemical Transport Experiment/Megacity Initiative-Local And Global Research Observations) the 14-channel Ames Airborne Tracking Sunphotometer (AATS-14) flew on the Jetstream 31 (J31) aircraft. AATS measured AOD at 13 wavelengths (354-2139 nm) and water vapor columns in 13 flights based in Veracruz, Mexico, sampling clean and polluted airmasses over the Gulf of Mexico and Mexico City. Vertical differentiation of AOD and water vapor column data from J31 vertical profiles yields vertical profiles of multiwavelength aerosol extinction and water vapor density. J31 flights were coordinated with overflights of several satellites, including Aqua, Aura, Terra, and Parasol, plus other aircraft, including the NASA DC-8 and King Air and the NCAR C-130. These coordinated flights produced a very rich data set with strong potential for OMI aerosol validation studies during J31-OMI coincidences.

An example of such a coincidence is the J31 flight over Mexico City on 19 March 2006. AATS measured vertical profiles and horizontal transects of AOD at the T2 site NNE of Mexico City and at the T0 site in the heart of the City, both of which were in OMI grid cells where aerosol retrievals were performed. The suborbital data set is particularly rich, including AERONET retrievals of aerosol properties from T2 and T0, additional aerosol retrievals from radiometers on the J31, and lidar and in situ measurements from the DC-8. This data set provides not only AOD values for comparison to OMI results, but information on aerosol height, size, and composition for constraining the OMI aerosol retrieval model. We show examples from the data set and discuss resulting insights into the OMI aerosol retrievals.

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Title: Spatial patterns in the seasonal evolution of ozone and CO as seen by TES, and the effects of the geographically variable a-priori used in the TES retrieval.

We present the seasonal evolution of TES data (V002) for ozone and CO from July 2005 onwards, with a focus on the tropics. A major feature in the southern tropics is a large scale ozone plume that develops in August and lasts into November. It emanates from the Brazil, the south Atlantic and Africa, and extends towards the Indian Ocean and possibly Australia. This feature, and many other spatial patterns evident the TES ozone product, are similar to those in the a-priori used in the retrieval. The ozone and CO a-priori profiles are derived from the MOZART model in bins of 10 x 60 (latitude x longitude) by month; the covariance matrices are derived from the model, as zonal means. We compare here the spatial distributions for the TES standard product to those derived using a universal a-priori, to determine the influence of the geographic distribution of the a-priori on the standard product. Many features seen in the standard product are found to be robust, but differences are found in detail. Artifacts apparent in the standard product, such as a gradient in ozone at 30 S in August-December, are absent when the universal prior is used. The use of a universal a-priori has a strong influence on the latitudinal gradient of ozone (and CO, as reported by Luo et al., submitted to JGR).

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Title: NOAA/NCEP Analysis/Forecast Model Update

An update of the NCEP operational analysis and forecast models' improvements and/or changes and their implications to the Aura science team.

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Title: Transport during the January/February 2006 Stratospheric Major Warming from Aura MLS and ACE-FTS data

A very strong and prolonged major stratospheric sudden warming (SSW) disturbed the circulation of the Arctic stratosphere in winter 2005-2006, leading to a nearly complete breakdown ofthe vortex throughout the stratosphere during middle to late January and February; a strong vortex reformed only in the upper stratosphere. With data from Earth Observing System (EOS) Aura Microwave Limb Sounder (MLS) and the ACE-FTS (Atmospheric Chemistry Experiment-Fourier Transform Spectrometer) instrument, we have an unprecedented wealth of trace gas data, particularly long-lived species, with which to study transport during the SSW throughout the stratosphere and lower mesosphere. We report here on studies in progress using MLS and ACE data, along with assimilated meteorological datasets, simulations with the SLIMCAT chemistry transport model, and high-resolution Lagrangian transport modeling, to provide a detailed picture of transport in the stratosphere and lower mesosphere during the 2006 major SSW.

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Title: Derived Meteorological Products for Solar Occultation Satellite Datasets and Applications to Aura Validation

Derived Meteorological Product (DMP) files have been produced for many solar occultation satellite datasets, as part of an ACMAP/Aura Validation project to help facilitate validation of non-coincident measurements. DMPs have been calculated for ACE-FTS,(Atmospheric Chemistry Experiment-Fourier Transform Spectrometer), SAGE (Stratospheric Aerosol and Gas Experiment) II and III, HALOE (Halogen Occultation Experiment), and POAM (Polar Ozone and Aerosol Measurement) II and III; similar files can be provided for user-defined data locations. The DMP products include temperature, potential temperature, horizontal winds, potential vorticity (PV), equivalent Latitude (EqL), vortex edge criteria, tropopause heights, and other useful quantities, derived from the UK Met Office meteorological analyses. There are also DMPs derived from GEOS-4 (NASA's Global Modeling and Assimilation Office's Goddard Earth Observing System V4.03 product) for ACE-FTS, and from NCEP/CPC (National Centers for Environmental Prediction/Climate Prediction Center) for SAGE II. A description of the DMP products is given; examples are shown using the DMPs to compare solar occultation measurements with Aura Microwave Limb Sounder (MLS) data in EqL/theta space.

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Title: Update on MLS Usage/Issues With Meteorological Datasets

An update will be given on behalf of the Aura Microwave Limb Sounder (MLS) Science Team on our usage of meteorological datasets and products derived from them. Issues regarding delivery to us and our processing of data from the meteorological centers will be updated, and examples of how we use these data routinely in processing and analyzing MLS data will be given.

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Title: Validation of HIRDLS Observations of Clouds and Aerosols

HIRDLS observes a variety of cloud and aerosols in the stratosphere and troposphere, i.e. polar stratospheric clouds, tropoapuse cirrus, opaque clouds, volcanic plumes, and background stratospheric aerosol. This talk discusses how correlative measurements can be used to validate preliminary multi-wavelength HIRDLS extinction measurements. Comparisons of HIRDLS extinction measurements to satellite data, and to CR-AVE aircraft

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Title: NATIVE (Nittany Atmospheric Trailer and Integrated Validation Experiment) Ozone Column and Profiles in INTEX-B/Milagro/IONS-06 and WAVES 2006: OMI Comparisons

The Pennsylvania State University NATIVE (Nittany Atmospheric Trailer and Integrated Validation Experiment) mobile research facility has generated a comprehensive suite of column and profile ozone measurements during participation in INTEX-B/Milagro/ IONS-06 in Houston, TX, and Richland, WA (March-May 2006) and WAVES 2006 in Beltsville, MD. Ozone vertical profiles were derived from En-Sci ECC ozonesonde launches; column ozone was calculated from the ozonesondes using the integrated profile values with the climatological total ozone amount from SBUV measurements above maximum balloon altitude. Column ozone values were also calculated using Langley analyses of UV shadowband radiometric measurements with climatological ozone values, and using a handheld Microtops II sun photometer/ozonometer. In Richland, WA, between 20 April and 15 May 2006, total column ozone amounts derived using the three techniques varied between 300 and 450 DU. Good agreement was found among the temporally averaged values calculated with all three techniques during the Richland campaign. Initial comparisons with OMI derived column ozone products (TOMS) over Richland show good agreement between satellite and ground based/balloon observations but for two roughly week-long periods. In both instances the satellite values were considerably lower than the NATIVE derived values. PV analyses at the 320 K level show large waves of polar air descending over the northwestern U.S. during the periods of disagreement. The satellite products may underestimate the tropospheric component of the total

column ozone during these periods, when ozone rich stratospheric air is intruding into the troposphere.

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Title: Status of EOS MLS Instrument Operations

The EOS Microwave Limb Sounder (MLS), on the NASA Aura satellite, launched 15 July 2004, is a follow-on to the Upper Atmosphere Research Satellite (UARS) MLS instrument launched in 1991. Its measurement suite includes simultaneous global measurement of vertical profiles of several atmospheric chemical constituents (O3, HCl,ClO, HOCl, BrO, OH, H2O, HO2, HNO3, N2O, CO, HCN, CH3CN, volcanic SO2), cloud ice, geopotential height, and temperature. The EOS MLS Operations Team operates the instrument in a manner to provide the greatest science return while also supporting special operations such as calibration events. This presentation provides historical status of EOS MLS instrument operations performance with respect to valid science data generation. In addition, this presentation will also provide the current operational status of the MLS instrument along with a few of the hardware and software challenges encountered since launch.

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Title: Mapping isoprene emissions from space using OMI formaldehyde measurements

Formaldehyde column measurements from OMI, onboard Aura, can provide new constraints on emissions of volatile organic compounds (VOC) from the Earth's surface. New measurements from recent field experiments (INTEX-A and B) allow us to quantify retrieval errors and to define the relationship between measured columns and VOC emissions. We use a 3D chemical transport model (GEOS-Chem) to interpret these datasets, characterize the errors in HCHO column retrievals, and show that isoprene drives observed HCHO column variability over North America. Formaldehyde column measurements from OMI can thus be used to define the spatial distribution of isoprene emissions. We will use the GEOS-Chem model to interpret the OMI data and the constraints they imply for North American isoprene emission patterns.

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Title: Variability of OH in the Middle and Upper Stratosphere

We investigate the observed behavior of hydroxyl in the middle and upper stratosphere using measurements from MLS. The daytime production of OH is thought to depend primarily on HOx source gases, H2O and O3 (both measured by MLS), and on the ozone photodissociation rate (primarily a function of ozone overburden and solar zenith angle, SZA). The MLS OH data can be segregated according to the corresponding H2O and O3 amounts in order to isolate the dependence of OH on SZA. Here, we find excellent agreement between MLS observations and a simplified model

of HOx photochemistry throughout the middle and upper stratosphere (~10 to 1 mb). In a similar fashion, the OH data can be binned by SZA to investigate correlations of OH with H2O and O3. We find a good correspondence between observations and the simple model near 10 mb at mid latitudes, but the results at 1 mb do not agree as well.

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Title: Convective influence of the near-tropopause region diagnosed from measurements of water vapor isotopic composition

Several recent papers have used trajectory models to study the ascent of air into the stratosphere and its desiccation to dry stratospheric mixing ratios. We report here on recent in-situ measurements of water vapor and its isotopic composition that call into question some of the assumptions in these models. Isotopic data were obtained during aircraft campaigns in tropics, subtropics, and midlatitudes in 2005-6. Measurements in the tropical tropopause transition layer (TTL) are inconsistent with simple gradual ascent to the tropopause. Instead, isotopic measurements suggest that significant amounts of water (and air) in the TTL region are derived from convective outflow. We show examples of convective outflows producing local isotopic enhancement near the base of the TTL and of convective ice observed at tropopause level. Convective rehydration of undersaturated near-tropopause air in warm regions of the tropics appears significant and must be included in models. Understanding convection to these altitudes is also important for modeling stratospheric and upper tropospheric chemistry, as deep convection brings air and its associated chemical constituents directly from the boundary layer to the near-tropopause region. We discuss how, with the help of additional in-situ or satellite tracer measurements, the isotopic profile obtained by our instruments may be inverted to obtain the vertical profile of convective detrainment flux.

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Title: HIRDLS Ozone Validation Update

An update of the HIRDLS ozone validation effort made to date is presented here. Comparisons of the latest corrected ozone retrievals are made with airborne and ground-based lidar, ozonesondes, ACE satellite-borne solar occultation measurements, AURA/MLS.

The HIRDLS ozone compared here are retrieved from the latest corrected radiances. The radiative properties of the unexpected visual obstruction, blocking over 80% of the HIRDLS field-of-view and described numerous times since Aura launch, must be well understood to a level of detail that includes their variability from sub-profile time-scales to inter-orbital time-scales. This is an ongoing effort. Comparisons will focus on current ozone accuracy, precision, vertical range, vertical resolution, effects of and possible improvements from complicating factors such as cloud presence.

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Title: Estimate of Stratosphere-Troposphere Exchange of Ozone Derived From MLS Observations

Daily high-resolution maps of ozone in the upper-troposphere/lower-stratosphere have been constructed using observations by MLS combined with trajectory information. The maps are used to determine the extratropical cross-tropopause transport of ozone for the year 2005 using two diagnostic methods. The resulting annual estimates and seasonal characteristics are compared with each other and past estimates.

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Title: Comparison of the Boulder water vapor record with UARS/HALOE and Aura/MLS observations

The completion of the HALOE observation record and the inauguration of the Aura/MLS measurements provides an opportunity to compare the long term Boulder balloon water vapor record with these two important satellite stratospheric water vapor time series. The Boulder, Colorado water vapor profile measurements obtained using cryogenic, chilled-mirror hygrometers flown on small balloons represent the longest time series of upper tropospheric and stratospheric water vapor. The HALOE water vapor measurements obtained from the UARS platform provided stratospheric water vapor measurements from 1992 through 2005. The Aura/MLS observational record began in 2004. The Boulder time series overlaps both time series and there are overlapping HALOE and MLS stratospheric water vapor profile observations. During the first half of the HALOE record the Boulder measurements and the HALOE observations over Boulder were in good agreement in their longer-term variation. During the latter half of the HALOE record (beginning in the late 1990s) the HALOE profiles over Boulder showed an increasing difference with the balloon profiles. This became most apparent after 2000 when the HALOE data show a sharper decline in the lower stratosphere than is seen in the Boulder profiles. While the HALOE record shows an overall decline in the lower stratosphere over its observational period, the Boulder time series over the same period shows a small increase. Over the extended Boulder record going back to 1980 there is a significant increase of a little less than 1% per year.

Comparison of the Aura/MLS profiles over Boulder with the balloon water vapor profiles shows generally good agreement with an average difference of about 5%. There is some altitude dependence in this difference, however, with MLS a bit lower at 68 hPa and about the same percentage higher at 14.7 hPa. Overall during the period of overlap between the HALOE and MLS records the HALOE profiles in the lower stratosphere are about 10% lower than those from MLS. At present it is not clear what the reason might be for the difference in the Boulder balloon time series and the record from HALOE.

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Title: Updated Validation Results for the Column Values of Ozone Measured by TES

We will show updated validation results for total ozone column, stratospheric column and tropospheric column values of ozone. The comparisons will show how the TES column values compare to OMI, MLS, SBUV and other measurements of column ozone. Global comparisons and time series will be shown to evaluate changes in the differences between measurements made by the different Aura instruments. Additional measurements made by aircraft and ground based instruments will provide further means of evaluating the TES column measurements.

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Title: An Update on the Use of GMAO Data for TES Level 2 Data Processing and Verification

The TES data processing software routinely uses the meteorological products produced by Goddard Space Flight Center Global Modeling and Assimilation Office. This talk will provide an overview of how TES uses the GMAO meteorological products and how changes in those products have affected data processing and quality.

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Title: Transport Above the Asian Summer Monsoon Anticyclone inferred from Aura MLS Tracers

Tracer variability above the Asian summer monsoon anticyclone is investigated using the Aura Microwave Limb Sounder (MLS) measurements of water vapor, ozone and carbon monoxide during Northern Hemisphere summer (June to August) of 2005. Observations show persistent maxima in carbon monoxide and minima in ozone in the monsoon UTLS region throughout summer, and variations in these tracers are closely related to the intensity of underlying deep convection. Temperatures in the UTLS are also closely coupled to deep convection (cold anomalies linked with enhanced convection), and the three-dimensional temperature patterns are consistent with a dynamical ‘Gill’ response to off-equatorial convection. Relative humidity derived from MLS data is high in the monsoon region (consistent with the frequent occurrence of thin cirrus clouds), and controlled by temperature fluctuations near the tropopause. Because the outflow of deep convection occurs near ~12 km, well below tropopause level (~16 km), we investigate mechanisms for upward transport within the anticyclone. We show that the mean vertical circulation obtained from the NCAR Community Atmosphere Model version 3 (CAM3) is upward within the anticyclone, as part of the balanced three-dimensional circulation. This mean upward circulation may explain the persistent constituent anomalies that extend into the lower stratosphere.

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Title: Assimilation of TES observations for the analysis of processes governing the chemistry of the troposphere.

Processes governing the distribution of tropospheric ozone and carbon monoxide (CO) from two

global models of tropospheric chemistry and transport are assessed through the assimilation of observations of ozone and CO profiles from the Tropospheric Emission Spectrometer (TES). The assimilation is based on a suboptimal Kalman filter and incorporates the GEOS-Chem model and a version of the NOAA GFDL general circulation model, AM2, with full tropospheric chemistry and dynamics nudged to NCEP reanalyses. Regions of enhanced ozone and CO are correlated in both models although the concentrations in GEOS-Chem are generally higher than those in AM2 throughout the troposphere. In particular, the GEOS-Chem concentrations in the mid to upper troposphere are up to approximately 20 ppbv higher than in AM2 in North America. Using the assimilation of ozone and CO measured by TES, we conduct a detailed analysis of the differences between the chemical and convective schemes utilized in each model.

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Title: GEOS-5

A brief overview of the GEOS-5 meteorological data assimilation system is given. Details of the model, the assimilation system and the included data will be given. Validation of key features against independent data and comparisons with GEOS-4 analyses will be presented.

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Title: CAFS partial ozone column data for in-flight validation of the AURA ozone products.

A comprehensive dataset of partial ozone columns was collected during Polar 2005, Houston 2005 and Costa-Rica 2006 Aura Validation Experiments (AVE). The spectrally resolved UV and visible actinic flux measurements were taken by the CCD Actinic Flux Spectrometer (CAFS) instrument on board of the DC-8 and WB-57 aircrafts. The algorithm to derive partial ozone columns from CAFS data was field-tested against ozone balloon measurement, as well as in-situ and remote-sensing measurements collected on board of the WB-57 aircraft platform, including ozone mixing ratio, ice content information and temperature measurements. An elaborate data set of partial ozone columns was provided for the first-round Aura satellite validation. Prior to the June 2005 AVE campaign the CAFS design was modified to reduce sensitivity to the variability of scattered light over inhomogeneous background. As a result, CAFS observations have become more sensitive to the aircraft roll and pitch movements. We present analysis of sensitivity of the CAFS product to the partial cloud scenes. Collocated Aura-MLS, SBUV (/16 and /17, V8), and OMI (SBUV V8 algorithm) ozone profiles have been derived for the two last AVE campaigns. Satellite ozone profiles integrated above the aircraft altitude are compared against CAFS partial ozone columns. Results indicate that MLS and CAFS agree within 3 %, SBUV and CAFS agree within 5 % (bias of 5 % at 12 km in AVE 2005, no bias in CR-AVE 2006), OMI/SBUV derived profiles agree within 5 % (bias of 2 %). Detailed analysis of the altitude-dependent bias between MLS and CAFS data is discussed. We also present CAFS and MLS errors

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Title: Clouds and Water Vapor in the Boreal Winter Tropical Tropopause Layer: Results from a trajectory-based microphysical model and comparison with satellite observations.

The Tropical Tropopause Layer (TTL), a region that surrounds the thermal tropical tropopause and extends from about 14 to 18 km, controls the input of water vapor into the lower tropical stratosphere. Though most convection does not penetrate the TTL, the convective turnover time is comparable to the radiatively driven vertical transit time. This makes the process of dehydrating tropospheric air to stratospheric values a complex mix of convective hydration (or dehydration) and in-situ dehydration by subvisible cirrus cloud sheets. Previous work has simulated water vapor and cloud distributions with reasonable success (based on comparisons with HALOE water and SAGE cloud data) using only in-situ dehydration processes.

This work examines both convective and in-situ processes by use of a one-dimensional, trajectory based microphysical model with convective injection. Water vapor and clouds are simulated by calculating 40 day back trajectories for 648 TTL parcels, and evaluating water vapor and a full spectrum if ice particle sizes along a time-varying vertical temperature curtain. Convective injection along the trajectories is based on time-varying geostationary satellite imagery, and the convective turnover times derived from our formulation are reasonably consistent with other estimates using independent methods. Results for the winter of 2005-06 using standard microphysics show that simulations including convection are superior to nonconvective calculations in representing observed water vapor distributions from EOS/Aura MLS. As in previous simulations for the 1995-96 winter, convection tends to hydrate the TTL. At 100mb, both convective and nonconvective cases show zonally averaged tropical values of about 2.4 ppmv, very close to MLS values. At 150mb, though, the convective simulations have values of about 13 ppmv, in agreement with MLS, and substantially larger than the nonconvective values of about 8 ppmv. In the horizontal, the contrast between wet and dry regions in the convective simulation is somewhat larger than the typical contrasts observed in the EOS/Aura MLS measurements. The representation of clouds by the simulations is in reasonable agreement with TTL cloud climatologies. Generally, cloud frequencies are: (1) in rough agreement with published ICESAT vertical cloud distributions and (2) somewhat higher for the convective cases.

The paper will focus on detailed comparisons of the model simulations with EOS/AURA MLS water vapor measurements for the winters of 2004-05 and 2005-06. These two winters are substantially different in their tropopause average temperatures, with 2004-05 being substantially warmer than 2005-06.

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Title: Improvements in Calibration and Retrievals for OH and HO2

Version 2.0 of the MLS level 1b calibration and level 2 retrievals will make significant improvements in the quality of OH profiles in the mesosphere while retaining validated performance in the stratosphere. In version 1.51 and 1.52, THz gain was assumed constant around the orbit while in fact the gain is observed to vary 1-4% over the orbit. We are now using an improved gain calibration that allows for sin, cos variation with orbital phase. Improvements in the retrieval are obtained by increasing the spatial resolution to a uniform 6 / decade in pressure that allows better radiance closure above 60 km. Other improvements in the iterative least square fitting have had a particularly beneficial effect on the OH product. Major changes in the HO2 have come from increasing the smoothing that damps the vertical oscillations present in the 1.51 product.

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Title: Interannual variability of entry level stratospheric water vapor over the Eastern Tropical Pacific during the wintertime

In this study, we analyze water vapor entry levels in the tropical stratosphere using in situ measurements of water vapor obtained from the Harvard Ly-alpha instrument flown aboard the WB-57 during the Pre-AVE (January 2004) and CR-AVE (January 2006) campaigns and space-borne measurements of water vapor from the Aura-MLS instrument (January 2005-06). We explore the interannual variability of water vapor above the tropical tropopause and compare the Eastern Tropical Pacific to the rest of the tropics during the wintertime. In addition, we use back trajectory calculations driven by ECMWF wind fields to investigate the leading mechanism and preferred location for dehydration for the air parcels sampled over the Eastern Tropical Pacific.

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Title: Observations of condensed-phase HNO3 in a tropical subvisual cirrus cloud

Observations in a tropical subvisual cirrus cloud during the Costa Rica Aura Validation Experiment (CR-AVE) on 2 February 2006 show the presence of condensed-phase HNO3 in the cloud. This cloud was observed at altitudes of 16-17 km in an extremely cold air mass (183-190 K). Ambient water vapor measurements show that relative humidities with respect to ice ranged from 100-240%. Optical particle measurements indicate the presence of large ice crystals in this cloud (50-100 μm diameter), as well as a particle mode in the 10-20 μm range. Ice particle surface area densities were typically less than 50 μm2 cm-3. The cold ambient temperatures produced nitric acid trihydrate (NAT) saturation ratios of 10 or greater during much of the cloud encounter, raising the possibility that HNO3 may be present in the cloud particles as a stable condensate, and not simply physically adsorbed on the particles. The partitioning of HNO3 between the gas and condensed phases near the tropical tropopause may be critical for understanding Aura instrument retrievals in this region. Furthermore, understanding the role of HNO3 in the formation and growth of cirrus ice particles may be important for assessing the contribution of subvisual cirrus clouds to the radiative forcing of climate change.

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Title: Validation of HIRDLS NO2

We show comparisons between HIRDLS measurements of NO2 and coincident measurements from other satellite instruments including the Atmospheric Chemistry Experiment (ACE), the Halogen Occultation Experiment (HALOE), and the Polar Ozone and Aerosol Measurement (POAM) III instrument. Coincidence criteria are \+/- 2 hours and 500 km. When too few coincidences are obtained with these criteria, they are relaxed; in this case, diurnal variations in NO2 are considered

with a photochemical model. We compare NO2 mixing ratio profiles as well as the variability measured by HIRDLS and the correlative instruments.

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Title: Observational characteristics of double tropopauses

Temperature profiles in extratropics often exhibit multiple tropopauses (as defined using the lapse rate criterion). In this work we study the observational characteristics of double tropopauses based on a variety of data sets. Double tropopauses are associated with a characteristic break in the thermal tropopause near the subtropical jet, wherein the low latitude (tropical) tropopause extends to higher latitudes, overlying the lower tropopause; this behavior can extend to polar latitudes. This phenomenon occurs frequently (in ~50-70% of soundings) in the NH during winter. Ozone measurements show that profiles with double tropopauses exhibit systematically less ozone in the lower stratosphere than those with a single tropopause. Together with the meteorological data, the ozone observations identify double tropopauses as regions of enhanced transport from the tropics above the subtropical jet cores.

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Title: Hydration of the Upper Troposphere by Tropical Storms

We use MLS and AIRS measurements in the tropical and subtropical upper troposphere (UT) to investigate the impact of tropical storms on water vapor distributions in this region. Changes in tropical UT water vapor can cause changes in the temperature structure of the atmosphere and at the surface. Our analysis shows that intense tropical storms effectively hydrate the UT in the vicinity of the storms by 10-40% above background levels. These storms also act to hydrate the entire ocean basin in which they occur and thus may be an important seasonal source of water vapor to the tropical UT.

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Title: Comparison of HIRDLS L1 and L2 data for Temperature O3 and H2O with ECMWF Analyses and Derived Radiance Data

HIRDLS radiance and geophysical data have been compared with analysis fields from the European Centre for Medium-Range Weather Forecasts (ECMWF). The ECMWF data for temperature, ozone and water vapor have been obtained for a number of days in the latest HIRDLS processing run. For comparison, the analysis fields, which are provided in a gridded format at standard synoptic times (00:00,06:00,12:00,18:00 UT), are interpolated in space and time to the locations of HIRDLS measurements and retrieved products.

In the radiance domain, measurements from channels 2-5 (temperature), channels 18 and 20 (water vapor), and channels 10-12, (ozone), have been examined. To validate the radiance data, HIRDLS radiances have been synthesized by applying the HIRDLS forward model to the ECMWF fields. These synthesized radiances have been compared with the corrected version of the HIRDLS radiance data which feeds directly into the retrieval processor.

For the geophysical products (L2), simple comparisons have been carried out at profile level and also as zonal averages with analysis data interpolated to the HIRDLS product locations. Only the currently released products of temperature and ozone have been assessed. The results indicate generally good consistency at both radiance and product levels. The HIRDLS radiances clearly capture the large-scale features of the atmosphere in all the channels examined. For the L2 products, temperature shows good agreement with the analyses and the morphologies of ozone fields are also similar. It should be noted that there is some uncertainty in the quality of the analysis data also, particularly in the case of stratospheric ozone and especially, water vapour, where there is believed to be a dry bias in the ECMWF model.

Results of comparison for a number of orbits/days are presented.

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Title: The Aura Validation Experiment: Scanning High-resolution Interferometer Sounder (S-HIS) Radiance Calibration Validation and Retrieval Products

The Scanning High-resolution Interferometer Sounder (S-HIS), developed and maintained by the University of Wisconsin-Madison Space Science and Engineering Center, is a dynamically aligned Fourier Transform Spectrometer. S-HIS has full spectral coverage in the spectral region from 580-3000 cm-1 with a resolution of 0.5 cm-1. Cross-track scanning via a 45° scene mirror results in ~40 km cross-track coverage with ~2 km footprints from a 20 km cruise altitude. The spectral and spatial coverage of the S-HIS provides good spectral and spatial overlap with nadir-viewing satellite instruments like TES, CALIPSO, and CloudSat. The S-HIS is an extremely well-proven instrument that has been flown since 1998 on the NASA DC-8 and high altitude aircraft, including the NASA ER-2, the Scaled Composites Proteus, and the NASA WB-57. The S-HIS has consistently demonstrated its value in satellite validation campaigns, including several for AIRS on Aqua and for the AURA Validation Experiments (AVE) of 2004, 2005, and 2006.

S-HIS participation in the Aura Validation Experiments has provided (1) Characterization of Tropospheric Emission Spectrometer (TES) radiometric performance, with a goal of improved product accuracy, (2) Assessment of tropospheric ozone retrievals from the Aura spacecraft using down-looking remote sensing that only views the troposphere, (3) Cloud properties from high spectral and spatial (~2 km) resolution IR measurements, and (4) Temperature and water vapor profile fields below the aircraft. Results from AVE-2004, AVE-2005, and Costa Rica AVE-2006 (CR-AVE) are presented.

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Title: Validation of TES Tropospheric Ozone Profiles with Airborne LIDAR Observations

The Tropospheric Emission Spectrometer (TES) conducts global measurements of tropospheric Ozone profile concentrations. Before they may be used for scientific study TES Ozone profiles must first be validated to determine if there are any systematic biases present. In this study we present a first attempt to validate TES tropospheric Ozone using airborne differential absorption LIDAR (DIAL) profiles obtained during the INTEX-B campaign. During INTEX-B the NASA DC-8 aircraft conducted several flights which allowed the DIAL instrument to obtain Ozone profile measurements which were spatially coincident with TES special observations in three different geographical regions.

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Title: ACE simultaneous upper tropospheric measurements of biomass burning emissions

Simultaneous measurements from ACE (Atmospheric Chemistry Experiment) 0.02 cm-1 resolution solar occultation infrared Fourier transform spectra show elevated upper tropospheric mixing ratios of CO, C2H6, HCN, CH3Cl, CH4, C2H2, CH3OH, HCOOH, and OCS during time periods of intense biomass burning in tropical-subtropical regions and in the Arctic during summer 2004.
Analysis of these relatively long-lived species is reported including the determination of emission factors. Results from ACE are compared with those from previous studies.

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Title: Ground-Based Validation of OMI NO2 Total and Partial Column Abundances Using High-Resolution Spectroscopy

The technique of solar occultation high resolution Fourier transform spectroscopy has been used to measure absolute diurnal NO2 column abundances for comparison with retrievals from OMI. The FTUVS instrument, located at JPL's Table Mountain Facility (TMF), resolves NO2 rovibronic features in the 420-500 nm spectral region with a resolving power of 400,000. The high spectral resolution, combined with the solar spectra acquired using the Doppler differencing method, permits the attenuation of solar lines without the use of a zenith reference spectrum, and therefore gives absolute NO2 column abundances. Although the complex terrain is not ideal for validation, comparisons with OMI NO2 column abundances show very good correlation provided the centroid of the OMI footprint is within 20 km of TMF. We will also present preliminary results from a retrieval method which separates the total column into tropospheric and stratospheric partial columns using information derived from the spectral lineshape.

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Title: Connecting UARS MLS and Aura MLS Upper Tropospheric H2O Data Sets

Measurements of upper tropospheric humidity (UTH) made with MLS instruments on the UARS and

Aura satellites are being compared with values from non-MLS data sets that were collected in near-coincidence with both UARS-MLS and Aura-MLS observations. Such non-MLS data collected consistently during the UARS (1991-1997) and Aura (2004-present) missions may be used as a transfer standard between the UARS and Aura MLS data. Radiosondes are an example of such non-MLS data, and will be the transfer standard examined most closely in this paper.

Our research goal is to determine a calibration correction between the UARS and Aura MLS data, enabling investigators to separate instrumental differences from atmospheric change between the UARS and Aura periods of operation. Numerous lower altitude studies have raised questions about regional-scale atmospheric differences between the UARS period and today. The Asian monsoon and El Nino cycle are two broad examples of research areas that stand to benefit from combined use of the UARS and Aura MLS data. Beyond enabling studies of decadal-scale change between the 1990s and today, calibrating the 1991-1997 UARS data to the 2004-present Aura data allows consistent analysis of a larger number of years, improving our understanding of interannual variability in the upper troposphere.

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Title: Validation of the Aura Microwave Limb Sounder HNO3 Measurements

We present preliminary Version 2 (v2) measurements of HNO3 in the stratosphere and upper troposphere from the Aura Microwave Limb Sounder (MLS). Changes from the previously-released v1.5 HNO3 data are discussed, and estimates of the expected precision and vertical resolution of the v2 HNO3 data are provided. Preliminary estimates of the accuracy of the v2 HNO3 data are obtained through limited comparisons with correlative measurements from other satellite, aircraft, and balloon instruments, as well as with a climatology of stratospheric HNO3 from the MLS instrument on the Upper Atmosphere Research Satellite.

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Title: Validation of the Aura Microwave Limb Sounder ClO Measurements

We present preliminary Version 2 (v2) measurements of ClO in the stratosphere from the Aura Microwave Limb Sounder (MLS). Changes from the previously-released v1.5 ClO data are discussed, and estimates of the expected precision and vertical resolution of the v2 ClO data are provided. Preliminary estimates of the accuracy of the v2 ClO data are obtained through limited comparisons with correlative measurements from other satellite and aircraft instruments, as well as with a climatology of stratospheric ClO from the MLS instrument on the Upper Atmosphere Research Satellite.

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Title: The influence of convection and midlatitude air on the water vapor and isotopic composition of the upper TTL and tropical stratosphere

We use recent in-situ observations of stratospheric H2O and HDO from the NASA WB-57 aircraft to study exchange between the tropics and midlatitudes. In both tropics and midlatitudes we measure unexpectedly heavy isotopic compositions of stratospheric water vapor, and we see surprisingly little isotopic gradient between the regions, despite the observed presence of isotopic enhancement by overshooting deep convection in midlatitudes. We examine the possibility that stratospheric isotopic homogeneity is indicative of significant exchange in the regions sampled. We show case studies of observed older air sampled in the tropics, with measurable differences in CO2, O3, H2O, and HDO/H2O. Backtrajectories suggest that a large fraction of sampled tropical air has recently traveled through latitudes higher than the subtropical jet. Aura MLS water vapor and ozone data, along with other in-situ measurements, are used to investigate whether this transport represents true mixing and permanent exchange.

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Title: An automated method for ozonesonde preparation and calibration

An automated method for preparation of the electrochemical concentration cell (ECC) ozonesonde is presented. Development of a computer-controlled system for preparation and calibration of the ECC is an improvement over the manual preparation method. Subjectivity associated with ozonesonde preparation is reduced considerably. Comprehensive evaluation of the ozonesonde performance over a large range of ozone concentrations also is possible. Retention of the preparation measurement parameters in digital form is found to aid analysis of the ECC prior to release and enhances post-flight certification, if necessary. It is expected that instrumental variability affecting long-term measurements will be reduced. This presentation describes the automatic system, gives examples of calibrations, and reduction of measurement noise. Further, the automated system enables comparison of different potassium iodide (KI) concentrations and allows adjustment of earlier ozonesonde observation data obtained with different KI concentrations previously used, i.e., 2, 1.5, 1, and 0.5 percent. Reanalysis of these data can re-establish a uniform Wallops Island database from 1970 to the present.

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Title: High Horizontal Resolution Tropospheric Ozone Residual from MLS and OMI

Forward trajectory transport of MLS ozone profiles in the lower stratosphere is used to produce a high horizontal resolution stratospheric ozone column. This column is then subtracted from the OMI column to produce a high horizontal resolution Total Ozone Residual (TOR). Preliminary evaluation of this TOR product shows that strat-trop folds dominate the mid-latitude fields on a day-to-day basis and even contribute to monthly mean estimates of ozone being transported out of Asia across the Pacific and out of the US across the Atlantic.

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Title: MJO in EOS MLS Cloud Ice and Water Vapor

MLS cloud ice and water vapor fields are used in conjunction with ECMWF analyses and TRMM rainfall rates to study spatial-temporal evolution of the Madden Julian Oscillation (MJO). MLS measurements provide unprecedented vertical resolution of ice and water vapor in the upper troposphere. MJO events are identified using extended empirical orthogonal function (EEEOF) analysis. Phase relationships between the fields and vertical correlations are examined.

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Title: Validation of EOS MLS Temperature

The MLS Temperature product and the height/pressure registration of MLS data products are discussed. A new version (v2.0) of MLS data products is currently under development which includes a temperature product with significantly better vertical resolution in the upper troposphere and tropopause region than that of the v1.5 product. Retrieval methods, precision estimates and vertical and horizontal resolution are discussed. MLS profiles are compared with interpolated analyses (GMAO, ECMWF, Met Office), and with nearly-coincident correlative temperature data sets (radiosondes, CHAMP, AIRS, HALOE, ACE-FTS and SABER.) Scatter and apparent biases are discussed.

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Title: Ticosonde Observations of Waves in the Tropical Tropopause Layer, 2004-2006

The four Ticosonde balloon-sounding campaigns in Costa Rica (10°N, 84°W) since 2004 together comprise an unprecedented set of high-frequency and high-resolution radiosonde data and profiles of water vapor and ozone to examine the temporal variability and vertical structure of the tropical tropopause layer (TTL). They also are a valuable resource for Aura validation studies. In each of the campaigns the temperature and wind profiles reveal a rich mix of laminations in the lower stratosphere. Water vapor and ozone profiles from the University of Colorado frostpoint hygrometer and ozonesonde payload indicate that some of these laminations have characteristics of mixed layers while others appear to be caused by waves propagating upward from disturbances in the troposphere. Laminations producing very cold tropopause temperatures are observed to produce dehydration, probably nearly local and very likely also due to synoptic scale ascent. These observations suggest that wave activity in the TTL play an important role in the control of water vapor at the threshold of the stratosphere. It also appears that the dynamic range of temperature anomalies at the tropopause produced by waves may be modulated by interannual variability, in particular the Quasi-Biennial

Oscillation. In this presentation we review the wave behavior in the three boreal summer and one winter Ticosonde campaigns and examine intraseasonal and interannual variability of the waves and laminations in the lower stratosphere.

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Title: Validation of TES Profiles using Radiance Closure Analysis

Comparisons are presented between the TES retrieved profiles of temperature, water vapor, and ozone and the sonde profiles in order to provide an overall evaluation of the retrieved products. When evaluating the profile differences in this type of comparison one must consider many possible error sources (e.g. instrument, forward model, retrieval, coincidence and collocation). Since the information for the retrievals comes from the radiances, a detailed analysis of TES measured radiances and forward model radiances provides additional insight into the relative importance of each of the possible error contributions. Presented are end-to-end radiance closure studies, where model radiance calculations using the resultant TES retrieved profiles, the TES initial guess (GMAO) profiles, and the corresponding comparison sonde are compared with the TES observed spectra.

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Title: International Polar Year (IPY): A brief report on the proposed POLARCAT mission

POLARCAT (POLar study using Aircraft, Remote sensing, surface measurements and modelling of Climate, chemistry, Aerosols and Transport) is an international experiment to be performed during the IPY 2007-8. The overall objective of POLARCAT, which proposes a coordinated program of measurements and modeling, is to quantify the impact of trace gases, aerosols and mercury transported to the Arctic and their contribution to pollutant deposition and climate change in the region. These scientific objectives will be addressed by the collection and analysis of data on trace constituents, aerosols and their radiative properties, heavy metals (mercury), CO2, O2, and precipitation composition at multiple surface sites. At certain sites, remote sensing instrumentation will also provide information on vertical distributions or columns of atmospheric constituents. Intensive international airborne campaigns are planned for winter/spring in 2007 and 2008 (Artic Haze) and summer 2008 (Forest Fires) involving multiple aircraft from several countries, a ship and real-time use of satellite data and forecast tools for planning. Satellite data validation and analysis (e.g. CALIPSO, TES, SCIA, ACE, GOME2, IASI) will also be a major component together with chemistry-aerosol-climate modeling, particularly in the assessment of inter-annual variations and impacts on climate. Plans for POLARCAT and ongoing activities for this international effort will be discussed.

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Title: Aura validation during the INTEX-B science campaign

Intercontinental Chemical Transport Experiment-B (INTEX-B) was completed in the spring of 2006 (http://cloud1.arc.nasa.gov/intex-b/)\. The main science goal of this experiment was to understand the transport and transformation of gases and aerosols on transcontinental/intercontinental scales and to assess their impact on air quality and climate. Central to achieving this goal was the need to relate space-based observations with those from airborne and surface platforms. In this context, validation of instruments aboard the Aura satellite (TES, OMI, MLS, HIRDLS) was a key objective within INTEX-B. The principal platform used for this purpose was the NASA DC-8 although the NSF/NCAR C-130 also performed specific activities useful for OMI validation. The DC-8 and C-130 were equipped to measure a vast majority of "standard" and "research" products to be retrieved from Aura instruments.

INTEX-B campaign was performed in two parts during the spring of 2006. The first part focused on the pollution from Mexico City and the second part on transported pollution from Asia. In the first part (March 1-21), the DC-8 operated from Houston, TX with sorties over Mexico and the Gulf of Mexico in partnership with the MILAGRO (MILAGRO (Megacity Initiative: Local and Global Research Observations; http://www.joss.ucar.edu/milagro/\) group. In the second part, the DC-8 was based in Honolulu, Hi (April 17-30) and Anchorage, AK (May1-15) with the NSF/NCAR C-130 operating from Seattle, WA (April 17-May 15) in a coordinated fashion.

The overall experiment was supported by forecasts from meteorological and chemical models, satellite observations, surface networks, and Ozonesonde releases. Aura representatives were present throughout the INTEX-B campaign to help plan and support validation activities. The DC-8 conducted 17 science missions and each of these included Aura validation components. All validation activities were carefully planned for timed coincidence along tracks of specific instruments. Two missions were specifically performed at night to provide validation for HIRDLS in the upper troposphere and stratosphere. Opportunities for validation included a variety of underlying surfaces, cloud covers, as well as varying distributions of trace gases and aerosols in space and time. We will provide a brief analysis of the INTEX-B experience specifically targeted for Aura validation.

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Title: New Multi Function Differential Optical Absorption Spectroscopy Instrument for Aura/OMI validation – Preliminary Results for NO2 from INTEX B

A new MultiFunction Differential Optical Absorption Spectroscopy (MFDOAS) instrument has been developed for ground based validation of the Aura/Ozone Monitoring Instrument (OMI). The instrument makes multiaxis sky observations (Honninger, G. et al. 2004) as well as direct sun measurements (Cede, A. et al. 2006) in the UV-visible spectrum for determination of NO2, O3, SO2, and CH2O columns. An RT code is used to convert to vertical columns and to derive spatial information on concentrations in the troposphere. The MFDOAS instrument was fielded in a prototype form at Pacific Northwest National Laboratory in Richland, WA during the INTEX B campaign 15 April – 15 May 2006. Results for tropospheric and stratospheric NO2 are presented.

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Title: Submillimeterwave Limb Sounder Observations for Aura Validation

The Submillimeterwave Limb Sounder (SLS) is a balloon-borne heterodyne radiometer that measures thermal emission of atmospheric gases using an ultra-sensitive SIS receiver. The instrumental

spectral window is in-flight frequency tunable from approximately 610 to 680 GHz permitting measurement of a large number of stratospheric gases including ClO, O3, HCl, HO2, HNO3, N2O, HOCl, BrO and H2O. High altitude balloon flights of the SLS were conducted (jointly with the JPL Mk IV and CfA FIRS-2 interferometers, JPL BOH and O3 photometer) in September, 2004 and 2005 from the CSBF balloon launch facility at Ft. Sumner, NM.
Concentration profiles of these gases, derived from measured radiances, are shown and compared with Aura and other balloon results

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Title: Tropospheric ozone from assimilation of Aura data using different definitions of the tropopause

Ozone data from Aura OMI and MLS instruments were assimilated into the general circulation model (GCM) constrained by assimilated meteorological fields from the Global Modeling and Assimilation Office at NASA Goddard. Properties of tropospheric ozone and their sensitivity to the definition of the tropopause are investigated. Three definitions of the tropopause are considered: (1) dynamical (using potential vorticity and potential temperature), (2) using temperature lapse rate, and (3) using a fixed ozone value. Comparisons of the tropospheric ozone columns using these tropopause definitions will be presented and evaluated against coincident profiles from ozone sondes. Assimilated ozone profiles are used to identify possible tropopause folding events, which are important for stratosphere-troposphere exchange. Each profile is searched for multiple levels at which ozone attains the value typical of the troposphere-stratosphere transition in order to identify possible tropopause folds. Constrained by the dynamics from a global model and by assimilation of Aura ozone data every 3-hours, this data set provides an opportunity to study ozone evolution in the upper troposphere and lower stratosphere with high temporal resolution.

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Title: The Iris Hypothesis Revisited: Analysis of Upper Tropospheric Cloud Variations with Sea Surface Temperature using Aura-MLS and Aqua-AIRS Observations

Using geostationary satellite data over the western Pacific warm pool, Lindzen et al. (2002) proposed a tropical infrared adaptive “iris” hypothesis in which upper tropospheric (UT) anvil cloud fraction, normalized by the fraction of deep convective cores, decreases about 22% per degree increase of sea surface temperature (SST), leading to a strong negative climate feedback. With the recent satellite observations of UT cloud ice water content profiles from Aura MLS, combined with the cloud fraction measurements from Aqua AIRS, we revisit the” Iris” hypothesis and examine the co-variability of UT clouds with SST. The preliminary results indicate that there is a weak negative correlation between daily high cloud amount and SST averaged over the western Pacific, but the UT cloud-SST relationship has large geographical and seasonal dependence. Furthermore, the radiative impacts of the MLS-observed UT clouds are explored using a simple radiative transfer model. It is found that the shortwave cooling effect of these clouds dominates over their infrared warming effect. Thus, the negative correlation of the UT clouds with SST would imply a positive cloud feedback. The coupling of clouds with water vapor will be considered separately.

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Title: Very Fast Delivery products of OMI

The Ozone Monitoring Instrument (OMI) operates onboard NASA's EOS-AURA satellite, which was launched in July 2004. Aura's capabilities include Direct Broadcast (DB), i.e. the ability to broadcast data at the same time as they are being measured and stored in the spacecraft's memory for later transmission to Earth. FMI's Satellite Data Centre at Sodankylä in Finnish Lapland is exploiting this capability to receive OMI data while Aura is in sight of the receiver, which enables nearly immediate production of OMI data products for a region that includes a large part of Europe, stretching from the North Pole to the Italian Alps.

The current OMI VFD (Very Fast Delivery) products include maps of surface UVindex, erythemal daily dose and ozone column. These products are meant to give information of UV radiation and ozone situation for everyone interested. The products are available through WWW-pages in fifteen minutes after the overpass of the satellite. From two to five overpasses are processed daily. The processing system and the WWW interface to the service will be described as well as the products will be introduced. Furthermore, the usability of the DB will be discussed.

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Title: Validation of the OMI Surface UV (OMUVB) product

OMI surface UV data have been compared with ground-based spectral UV measurements. We present the validation results that imply that there is a need to account for absorbing aerosols to get rid of the current positive bias of the OMI surface UV data. We present a plan for development of a correction for absorbing aerosols that includes selection of suitable validation cases and aerosol data sets, and testing of various correction algorithms.

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Title: NATIVE (Nittany Atmospheric Trailer and Integrated Validation Experiment) Remotely Sensed Aerosol Optical Properties: Examples from INTEX-B and WAVES 2006

The Pennsylvania State University NATIVE (Nittany Atmospheric Trailer and Integrated Validation Experiment) mobile research facility has participated in INTEX-B in Houston, TX and Richland, WA, and WAVES 2006 in Beltsville, MD. NATIVE uses several complementary remote sensing techniques to derive aerosol optical properties from the near UV to the near IR. Aerosol optical depth was derived via Langley analysis at 7 discrete UV wavelengths from 299 to 367 nm with a shadowband radiometer. A Cimel sun photometer (part of AERONET) was used to determine AOD at 8 wavelengths from 340 to 1020 nm. A handheld Microtops II sun photometer derived AOD at 340 and 380 nm, two wavelengths that overlap those from the Cimel. The MAGCL (Meteorology Aerosol

Green Compact Lidar) is the NATIVE 532 nm aerosol Lidar that operated sporadically during the INTEX-B campaigns and nearly continuously during the WAVES 2006 campaign at the Howard University Beltsville Research Site. Molecular backscatter data were removed from the MAGCL measurements using P-T data from the coincidental radiosonde launches performed on a daily basis during the INTEX-B and WAVES campaigns. The MAGCL lidar derived backscatter and extinction coefficients were then calculated and the vertically integrated extinction coefficients were calibrated using the NATIVE Cimel AERONET derived AOD interpolated to 532 nm. The complement of measurements across multiple wavelengths will allow for the derivation of the single scattering albedo and aerosol size information. The MAGCL lidar will provide the vertical distribution and dynamical information as well as cloud height data important for deriving satellite aerosol products.

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Title: IONS-06 (INTEX Ozonesonde Network Study): Variability in UT/LS Ozone and Implications for Aura Ozone Retrievals and Assimilation Products

As part of INTEX-B (Intercontinental Chemical Transport Experiment)/Milagro and Aura Validation, ozonesondes were launched in the greater Mexico City area (Tecamec site: 19.4N, 98.6W) and Houston (29.7N, 95.4W) in March 2006, during Phase 1 of IONS-06 (INTEX Ozonesonde Network Study; http://croc.gsfc.nasa.gov/intexb/ions06.html). The focus was on pollution in the late dry-season in Mexico and central America, when a secondary maximum occurs in the annual cycle of surface ozone. In Phase 2 of INTEX-B/Milagro/IONS-06, April-May 2006, soundings were taken in Richland, Washington, when transport of Asian outflow is greatest. Pollution episodes were identified at all sites and estimates of advected tropospheric ozone are presented. Furthermore, at all three sites, wave activity was manifest in the UT/LS in stable ozone and potential temperature laminae. For example, a 20% and 50% frequency of Rossby and Gravity waves, respectively, appeared in the Mexico City soundings. We examine the ways in which the differentiation of stratospheric and tropospheric ozone in the UT/LS is affected by these waves and implications for comparing sonde data with tropospheric and total ozone products based on OMI.

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Title: AURA validation by the balloon-borne MkIV Interferometer

The JPL MkIV interferometer performed two balloon flights from Ft. Sumner, New Mexico (34.4N, 104.2W), during September 2004 and 2005, respectively,
in order to measure profiles of atmospheric trace gases of relevance to the AURA sensors. High signal-to-noise ratio solar spectra were measured throughout the mid-infrared region (650 -- 5650 cm-1) at high spectral resolution (0.01 cm-1) during balloon ascent and at sunrise and sunset.

These spectra allow the simultaneous retrieval of profiles of more than 30
different atmospheric gases including H2O, O3, HCl and NO2 which are measured by sensors on board the AURA spacecraft. On the same gondola were the Far Infrared Spectrometer (FIRS-2), the Stratospheric Limb Sounder (SLS-2) and the Balloon OH terahertz heterodyne spectrometer (BOH). The in-situ UV O3 photometer was also a part of the instrument payload during the September 2005 balloon flight.

We will present MkIV measurements of H2O, O3, CO, CH4, CH3CN. HCN, Cly, NOy, etc. used for the validation of AURA measurements. A fundamental difficulty that was overcome in the validation of measurements from the AURA instruments is that the AURA sensors observe around 1:30 and 13:30, whereas the MkIV balloon measurements are obtained at sunrise or sunset. We have used a photochemical model to scale the MkIV observations to the local time of the AURA measurements. It is a reasonable approach for examining the overall consistency between photochemical theory and the MkIV and AURA measurements of long-lived reservoir species, such as HNO3.

In addition to the two balloon flights, the MkIV team continued development of the Light Weight Balloon Interferometer (LWBI). In particular, the Brault-scheme for time-domain dual-channel signal acquisition was designed and tested in collaboration with University of Liege. Spectra from these tests are presented.

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Title: The 2006 Boreal Forest Fire Season as seen by OMI

Extensive boreal forest fires over Canada and Western Siberia took place during July 2006. On the first week of July a series of fires originating in Alberta, Canada quickly traveled in a southeast direction reaching the US east coast in about four days. The smoke plume from these fires was clearly detected by the OMI sensor and by ground-based sun-photometer and lidar observations. On the last week of July boreal forest fires in Western Siberia generated an optically dense smoke layer that covered a large region of northwest Russia for over a week. We will discuss the satellite and ground based observation of these events, and elaborate on the inferred optical characteristics of the aerosol plumes.

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Title: Comparison of lower stratospheric ozone, as modeled by MIMOSA-CHIM, and observed by EOS MLS over the period September 2004 – May 2005

A new version of the three dimensional Chemistry-transport model MIMOSA-CHIM dedicated to the study of lower stratospheric ozone has recently been implemented at JPL. The first results from this new model version will be compared to the EOS MLS measurements onboard Aura over the period September 2004-April 2005. Particular emphasis will be made on a polar ozone filament of rare extent that reached latitudes as low as 20ºN in March 2005. This filament was observed simultaneously by the JPL lidar at Mauna Loa Observatory, Hawaii, and by MLS. This event, occurring between 415 K and 455 K, was seen on both the lidar and MLS profiles as a layer of enhanced ozone, peaking at 1.7 ppmv in a region where the climatological values are usually around or below 1 ppmv. During that particular event, the agreement between lidar, MLS, and MIMOSA-CHIM is excellent considering the difference in the sampling techniques. MLS was also able to identify the filament at another location North of Hawaii. The end of the 2004 Southern hemisphere winter, as modeled by MIMOSA-CHIM, and observed by MLS will also be discussed

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Title: HIRDLS - AROTAL Lidar comparisons during INTEX-B

During the INTEX-B mission the DC-8 flew many flights which included intersections with Aura instrument flight tracks. On two separate occasions, however, during transits between deployment locations, the DC-8 flew long tracks along the HIRDLS tangent point. These flights were conducted during the nighttime overpass, when the AROTAL instrument operates optimally. The first flight was the transit from Houston, TX to Moffet Field, CA on 3/22/06 UT and the second was the transit from Honolulu, HI to Anchorage, AK on 5/1/06 UT. Data from the HIRDLS team for the night of 5/1 has just recently been made available, and data for the earlier transit to Moffet field will shortly become available. This will represent one of the first opportunities to compare HIRDLS data with a long flight tracks of several hours duration. The results of these comparisons will be shown and discussed in this paper.

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Title: Information on Atmospheric Aerosol in OMI Measurements

Atmospheric aerosol is monitored using OMI (Ozone Monitoring Instrument) measurements of reflected sunlight in a series of narrow wavelength bands between 331 nm to 500 nm. A Principle Component Analysis (PCA) is performed to quantify the information content of OMI measurements on aerosols. This analysis is applied to synthetic measurements for desert dust, biomass burning and weakly absorbing aerosol with a variety of aerosol optical depths, aerosol layer heights, refractive indices and size distributions. The range of aerosol parameters considered covers the natural variability of atmospheric aerosols. This analysis is performed for a large number of scenarios with various geometries and surace albedos for ocean, soil and vegetation. When the surface albedo is accurately known and clouds are absent, OMI measurements have 2 to 4 degrees of freedom that can be attributed to aerosol parameters. This information content depends on the observation geometry, the surface albedo, and on the aerosol parameters themselves. An additional wavelength band is evaluated, that comprises the O2-O2 absorption band at a wavelength of 477 nm. This wavelength band adds significantly more information than any other individual band. The PCA is applied to assess the capability of the aerosol retrieval to discern various aerosol types as well as clouds.

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Title: Validation of AURA/MLS water vapor observations using the Cryogenic Frostpoint Hygrometer (CFH) and comparisons with the WB57 aircraft water vapor instruments and the Vaisala RS92.

AURA/MLS water vapor observations are compared to balloon borne in situ measurements using the University of Colorado Cryogenic Frostpoint Hygrometer (CFH) at a number of tropical, mid-latitude and polar sites. At and above 100 hPa these observations show agreement between MLS and CFH water vapor within 10% for mid and high latitudes during all months and at equatorial sites during the

northern summer. During the northern winter there is an altitude dependent disagreement of up to 30% at tropical sites. At the upper tropospheric levels MLS measures dry compared to the in situ observations; however, this result is not statistically significant due to the much larger variability of MLS water vapor compared to the in situ observations in this vertical region. Vaisala RS92 daytime observations cannot be used without corrections to evaluate the upper tropospheric water vapor.

The comparison of CFH water vapor observations with observations onboard the WB-57 aircraft during CR-AVE shows large disagreements between the balloon borne and the aircraft measurements, which far exceed the instrumental uncertainties. Disagreements are largest at the tropopause and above.

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Title: Dehydration, cirrus clouds, and wave activity in the tropical tropopause layer during the warm and cold tropopause temperature season

A considerable number of campaigns studying the tropical tropopause dehydration processes have taken place during the northern winter months, which corresponds to the season of cold tropopause temperatures. Few observations have taken place during the season of warm tropopause temperatures. Ticosonde-Aura campaigns took place at Alajuela and Heredia, Costa Rica in July 2005, January/February 2006 and July 2006, with frequent launches of CFH water vapor instruments and ECC ozone sondes in cooperation with the Laboratory for Atmospheric Chemistry (LAQAT) of the Universidad Nacional at Heredia. These sondes provide detailed observations of the water vapor and ozone in the tropical atmosphere from the surface to the middle stratosphere. The observations took place both during the warm and cold tropopause temperature season. During the northern summer season the tropopause region exhibits water vapor amounts generally higher compared to mean stratospheric values. However, the coldest tropopause events during July-August show drying to well below mean stratospheric mixing ratios.

Radiosondes, which were launched 4 times daily, provide a high resolution picture of temperature and wind in the upper troposphere and lower stratosphere and show that the cold events are related to wave activity in the UTLS region. There is a strong correlation between the anomalies in temperature, zonal wind and ozone.

Simultaneous observations of water vapor using the CFH and lidar backscatter ratio at Bandung, Indonesia in December 2004 and at Biak, Indonesia in January 2006 provide the first correlation data between CFH relative humidity and cirrus clouds in the tropical western Pacific region. These observations indicate that large values of supersaturation can be achieved, and that the largest values are typically reached in the absence of cirrus clouds. The comparison of observations at Biak and at Heredia, Costa Rica in January 2006 show, that the coldest air, the lowest amounts of water vapor and the largest values of supersaturation over ice is observed in the Western Pacific region, in agreement with the geographic distribution of the coldest tropopause regions. Wave activity is able of modifying the occurrence of high supersaturation and clouds at the tropopause.

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Title: Level 3 Product Specifications in the New Aura Guidelines

The Aura Guidelines is a document containing common specifications that the different Aura instrument teams have agreed to adopt for their data products. Data users can therefore read the products of different instruments using a single tool. The Guidelines already contained specifications for Level 2 products. The new version of the Aura Guidelines contains an additional section specifying how Aura instrument teams will structure their Level 3 products.

MLS will present information about the new Level 3 specifications. They will also describe the Daily and Monthly products and metadata files that MLS will produce according to the Level 3 specifications, and in particular the Grid and Zonal Mean types.

MLS has been producing, archiving and distributing Level 2 products to users and investigators since February 2005. They have been publicly available since August 2005. The MLS Level 3 software is currently under development and will be released before September 2006.

The Earth Observing System (EOS) Microwave Limb Sounder (MLS) is an atmospheric remote sensing experiment led by the Jet Propulsion Laboratory of the California Institute of Technology.

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Title: The Atmospheric Chemistry Experiment (ACE): Mission Update

The Atmospheric Chemistry Experiment (ACE), also known as SCISAT-1, is a Canadian scientific satellite to perform remote sensing measurements of the Earth's atmosphere. It was launched on August 12, 2003 and has been operational for over 2.5 years. The primary instrument on-board SCISAT-1 is a high-resolution (0.02 cm-1) Fourier Transform Spectrometer (ACE-FTS) operating between 750 and 4400 cm-1. It also contains two filtered imagers to measure atmospheric extinction due to clouds and aerosols at 0.525 and 1.02 microns. The secondary instrument is a dual UV-visible-NIR spectrophotometer called MAESTRO (Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) which extends the wavelength coverage to the 280-1030 nm spectral region.

The primary measurement technique for both instruments is solar occultation. From these measurements, altitude profiles of atmospheric trace gas species, temperature and pressure are obtained. The 650 km altitude, 74 degree circular orbit provides global measurement coverage with a focus on the Arctic and Antarctic regions. The primary goal of the ACE mission is to measure and to understand the chemical and dynamical processes that control the distribution of ozone in the upper troposphere and stratosphere, with a particular emphasis on the Arctic region. The mission status, current science results and validation program will be reviewed in this paper.

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Title: A Framework for Tropospheric CO comparisons Between TES and AIRS

The validation study for TES tropospheric CO using AIRS CO products is funded by NASA’s AURA validation program for the period of June 2006 to May 2009. This poster will describe the approaches we take to carry out this work and our plans for data management and sharing within the AURA science community. We will also show examples of AIRS CO validated against in situ CO measurements, as well as its comparison with MOPITT CO, based on previous studies to

demonstrate the quality of AIRS CO products. Preliminary results from the comparison of TES and AIRS CO will include study cases from the INTEX-B and MILAGRO experiments.

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Title: MLS and AIRS measurements of water vapor and ozone in the subtropical upper troposphere

We examine the distribution and variability of water vapor and ozone in the subtropical upper troposphere using measurements from the Aura MLS and AIRS instruments. We focus on the northern subtropics during winter, and examine the mean distribution as well as variability on daily and intra-seasonal time scales. These variations are related to different processes, including stratospheric intrusions, tropical convection, and the Madden-Julian Oscillation. Comparisons are also made between MLS and AIRS measurements

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Title: Comparison between HIRDLS and MIPAS radiances and key retrieved species.

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) is an infrared Fourier transform spectrometer on ESA's ENVISAT satellite which was launched in March 2002. MIPAS is a limb viewing instrument which operated over a spectral range of 685-2410 wavenumbers. The original spectral resolution of MIPAS was 0.025cm-1 but since August 2004 MIPAS has been operating at a reduced resolution of 0.0625cm-1.

Direct radiance comparisons between HIRDLS and MIPAS have been produced for the 10 HIRDLS channels which are completely covered by the MIPAS spectral bands. These spectra have also been compared to TES measurements.

At present there is no operational ESA level 2 product for the reduced resolution observations, but a local optimal estimation retrievals code (the MIPAS Orbital Retrieval using Sequential Estimation (MORSE) has been used to retrieve volume mixing ratio (VMR) profiles for key atmospheric species from the ESA level 1B MIPAS data.

These retrievals were used as the input atmosphere in a forward model (the Oxford Reference Forward Model (RFM)) to create a simulated MIPAS radiance spectrum which covered the full HIRDLS spectral range. This simulated spectrum allows the MIPAS radiances to be indirectly compared to the HIRDLS radiances for those channels for which a direct comparison is not possible.

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Title: Troposphere-to-stratosphere transport mechanisms: Insights from recent measurements on the role of direct convective injection into the stratosphere

The impact of overshooting cumulus convection on the stratospheric water vapor budget has been a

matter of debate for several decades. I will focus on using in situ Harvard water vapor, total water and water isotope data, taken both in the tropics and midlatitudes, to address this issue. While dehydration through slow ascent through a temperature minimum to the ice saturation value (or at least close to it) accompanied by particle sedimentation may be the predominant mechanism controlling the stratospheric water vapor budget, how important is the role that direct convection into the stratosphere plays\? Do we see evidence of (1) Dehydration through convection directly into the stratosphere accompanied by particle formation and sedimentation; (2) Hydration through convective lofting of ice particles followed by evaporation in the tropics\? (3) Hydration through convective lofting of ice particles followed by evaporation in midlatitudes? In-situ data collected by the Harvard Lyman-alpha water vapor instrument imply that convection helps to hydrate the stratosphere. We have observed numerous incidences of anomalies in stratospheric water attributed to deep convection; these are almost invariably positive. We show preliminary seasonal and regional dependences of these anomalies based on in-situ data from the NASA ER-2 and WB-57 aircraft. The time- and spatial-coverage of these missions is however too sparse to obtain a meaningful estimate of the global contribution of deep convection to the stratospheric water budget. The Aura satellite coverage, however, spans the full range of longitudes and extends from tropics through midlatitudes. We suggest possible approaches for analysis of satellite data that could allow us to determine the convective contributions in the different regions and to compile a global estimate of the impact of convection on stratospheric water.

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Title: Water Vapor Validation Experiment - Satellite/Sondes - Overview and preliminary results

The NASA AURA satellite was launched on July 15, 2004 and is the trailing member of the A-train series of satellites. AURA carries the HIRDLS (High Resolution Dynamics Limb Sounder), MLS (Microwave Limb Sounder), OMI (Ozone Monitoring Instrument) and TES (Tropospheric Emission Spectrometer) instruments. Among the main goals of the AURA mission is the quantification of atmospheric water vapor, ozone and air quality using these instruments. A field campaign called WAVES_2006 (Water Vapor Validation Experiment - Satellite/Sondes) was held this past summer to provide research quality measurements of these and other quantities for comparison with AURA satellite retrievals and for instrument accuracy assessment studies. Because of the small difference in overpass time, we will also be studying Aqua satellite retrievals.

WAVES_2006 (http://ecotronics.com/lidar-misc/WAVES.htm) was hosted at the Howard University Research Campus in Beltsville, MD officially from July 7 - August 10, 2006. The Howard University site was selected to host WAVES because of the extensive suite of atmospheric measurement instrumentation sited there through the support of NOAA and cooperative agreements with the Maryland Department of the Environment (MDE) and WTTG FOX television. Measurements of surface latent heat and carbon dioxide fluxes, boundary layer height and evolution, cloud optical and physical properties, aerosols, gas concentrations, and precipitation are available to support intensive field operations such as WAVES. The measurement systems include 31-m instrumented tower, various broadband and spectral radiometers, microwave radiometer, whole sky imager, Raman lidar and Doppler C-band radar. Research level air quality monitoring is also conducted at a collocated site operated by MDE. A complete set of gas, filter (including 56 organic species) and particulate measurements (PM2.5 and 10) are made at this site along with surface meteorology and upper air observations with a wind profiler and RASS system.

WAVES is serving to bring together researchers from several U.S government agencies and universities and foreign institutions as well. As such it provides a unique training opportunity for

students in the atmospheric sciences. Undergraduate and graduate students from both the U.S and several foreign countries will be participating. Students will be involved in ozonesonde preparation and launch, lidar data acquisition and analysis and in performing daily regional forecasts using the Weather Research and Forecasting (WRF) model.

The operations plan for WAVES included intensive observations by multiple radiosonde/ozonesonde sensors and several lidar systems during approximately 30 overpasses of the AURA satellite. Special staring-mode observations of the Beltsville region were programmed for the TES instrument during the period of the WAVES campaign which increased the amount of coincident data for evaluating an updated TES ozone retrieval algorithm. Quick turn-around water vapor and ozone retrievals were provided by the AIRS team at NOAA/NESDIS for comparison. Radiosonde systems manufactured by Vaisala (RS92 and RS80), Intermet and Sippican were tested during WAVES. The National Weather Service (NWS) began deploying the Sippican package in March 2006 to several of its upper-air launch sites. NWS will also be engaged in Consensus Reference Testing, which involves evaluating data from a suite of technologies in order to converge on a statistical and repeatable set of acceptable thresholds for a particular parameter under review. Research-grade balloon borne packages that were used during WAVES included the University of Colorado Cryogenic Frostpoint Hygrometer (CFH) and the NASA/GSFC ATM multi-thermistor radiosonde system. The ATM instrument uses 3 temperature sensors with different emissivity characteristics to provide an improved measurement of atmospheric temperature. The CFH is the instrument that was used as the water vapor reference sensor during AWEX-G [1,2], an experiment in 2003 that will serve as a model for the radiosonde intercomparison/satellite validation activities that will result from the WAVES measurements. Lidar measurements were acquired at the Beltsville site during WAVES by the permanently stationed Howard University Raman Lidar (HURL) and by the visiting NASA/GSFC Scanning Raman Lidar (SRL) and Aerosol/Temperature Lidar (ATL) and a MicroPulse Lidar from Penn State. Coordinated backscatter (Elastic Lidar Facility) and Raman (Atmospheric Lidar Experiment) lidar measurements also were obtained from the University of Maryland, Baltimore County. These coordinated lidar measurements from three sites separated by 10-30 km will permit the spatial variability of aerosols and water vapor to be studied on scales of interest in satellite retrievals. The Penn State University NATIVE trailer containing extensive gas sampling and radiation measurement instrumentation was also deployed to the Beltsville site for WAVES. The measurements from this system are being compared with comparable measurements from the MDE instrumentation adding to the confidence level of the trace gas validation data. A member of the SuomiNet network of GPS systems is being lent by NASA/GSFC for total column water measurements. More details of the WAVES operations and preliminary science results will be described at the symposium.

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Title: TES-ozonesonde comparisons: updates from Costa Rica AVE, ARM-SGP and IONS

We present comparisons of ozone profiles using the latest TES data version (V002) with sonde data from 2006 campaigns. Many of the sondes were launched to coincide with the Aura overpass. These comparisons have shown that V002 data have much smaller ozone biases than V001 data. They have also revealed problems in the ozone retrieval for particular types of temperature profile and thermal contrast, leading to a new data quality flag for TES.

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Title: TES observations of the tropical lower troposphere in January 2005 and 2006

We present ozone and carbon monoxide measurements for the lower troposphere (around 750 hPa) for the month of January in 2005 and 2006. Elevated ozone is persistent over Northern Africa, the Middle East and India and we find significant differences between TES and OMI total column ozone estimates for these regions. However, the TES measurements are in qualitative agreement with previous measurements of tropospheric column ozone retrieved from UV data using the scan angle method. We also see elevated carbon monoxide, corresponding to Northern Africa biomass burning regions, in agreement with MOPITT. TES ozone profiles for the tropics are compared to ozonesondes, where available.

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Title: Improved Tropospheric Ozone Profiles using OMI and TES Radiances

We perform a synthetic study for simultaneous retrieval of tropospheric ozone profiles from the Ozone Monitoring Instrument (ultraviolet measurements, UV) and the Tropospheric Emission Spectrometer (thermal infrared measurements, IR), both on board the EOS Aura satellite. The study is for a November 2005 orbit of Aura that crosses the Caribbean and then North America at about –80o longitude. Synthetic ozone fields are taken from the GEOS-CHEM 3-dimensional chemistry and transport model. We find that estimating ozone profiles by combining UV and IR radiances results in a factor of two or more improvement in the ability to resolve boundary layer ozone, as compared with either instrument alone as well as a substantial improvement in the vertical resolution of ozone in the free troposphere (between 20% and 60%) as compared to the TES vertical resolution. This study points towards the importance of combining multiple spectral regions for dramatically improving the sounding of tropospheric trace gases.

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Title: Regulation of H2O and CO in Tropical Tropopause Layer by the Madden-Julian Oscillation

Impacts of the Madden-Julian oscillation (MJO) on the water vapor (H2O) and carbon monoxide (CO) in the tropical tropopause layer (TTL) are investigated using Aura Microwave Limb Sounder (MLS) data for November 2004 to April 2005. The eastward propagation of deep convection in the H2O and CO fields in the TTL is evident. Tropical mean water vapor at 370 K is regulated by the MJO through the variation of temperature with a timescale of about 40-50 days. Enhancement of deep convection associated with the MJO also injects CO from the lower troposphere to the lower stratosphere. However, tropical mean CO at 370 K responds instantaneously to the large surface emission over the African continent. The regulation of TTL CO by the MJO is through the enhancement of deep convection over the African continent and is less evident than that of H2O.

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Title: Mesospheric Doppler Wind Measurements from Aura Microwave Limb Sounder (MLS)

Mesospheric winds have large spatiotemporal variability and observations are sparse. Some earlier space observing techniques, including UARS HRDI (Upper Atmosphere Research Satellite High Resolution Doppler Imager) (Hays et al., 1993) and TIMED TIDI (Thermosphere Ionosphere Mesosphere Energetics and Dynamics Doppler Interferometer) (Killeen et al., 1999), are mainly based on daytime visible airglow emissions.

This paper describes a new technique to measure mesospheric winds using the 118-GHz oxygen emission observed by Microwave Limb Sounder (MLS) on NASA Aura satellite. Resolving Doppler shift of the narrow 118-GHz O2 emission lines, MLS can detect the line-of-light (LOS) wind speed with a precision of ~15 m/s in 1/6 second integration time. Because Aura is a polar-orbiting satellite and the MLS views in the forward direction, the winds observed by MLS are primarily in the meridional direct at the low-and-mid latitudes. During January and June-August 2005, MLS observed strong 2-day wave oscillations, which is consistent with the amplitude measured by TIDI during the same period.

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Title: MLS version 2 cloud ice and validation plan

In this presentation we will report progress in developing MLS version 2.0 retrieval algorithm for cloud ice product, and discuss changes and improvements of MLS v2.0 over v1.5 on IWC (ice water content) and IWP (ice water path). We will also discuss plans for validating/comparing MLS cloud products to correlative measurements with some preliminary thoughts and results.

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Title: Aura tropospheric ozone columns derived from OMI-MLS measurements

More than one year of OMI-MLS derived tropospheric ozone columns have been extensively analysed through comparisons against mid-latitude ozonesonde measurements. The stratospheric columns used consist of MLS columns down to 215 mb, and when the tropopause is below that altitude, ozone obtained from PV mapped SAGE II profiles (typically 5-10 DU) has been added. The derived tropospheric columns are, in the mean, 3-5 DU smaller than ozonesonde column measurements, and the standard deviations of the differences are less than approximately 10 DU in summer/fall and 15 DU in winter/spring. These differences are associated with differences in lower stratospheric columns from 215 mb to 700K potential temperature (approximately 27 km altitude) which are approximately 10 DU larger than the corresponding ozonesonde columns. The standard deviations in the differences in the lower stratospheric columns versus ozonesondes are similar to those for the tropospheric column differences. Compared to SAGE measurements the MLS stratospheric profiles are also high in the lower stratosphere (below 100 mb) but this is mostly compensated by lower MLS values in the upper stratosphere. As a result there appears to be a calibration offset of approximately 1% between MLS and OMI measurements (MLS higher). PV mapping of MLS columns over up to 8 degrees of

longitude only reduces the standard deviations of the differences on a few occasions during winter/spring; however a substantial improvement is produced when an orbit of data is missing. Meteorological assimilation models with resolutions better than 250 km might produce improved mapping results.

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Title: A cross-evaluation of tropospheric ozone from Aura OMI/MLS and DIAL lidar measurements during INTEX-B

Tropospheric O3 mixing ratio derived from Aura Ozone Monitoring Instrument (OMI) total ozone and Microwave Limb Sounder (MLS) stratospheric column O3 residual is compared with Differential Absorption Lidar (DIAL) O3 measurements during the INTEX-B campaign (March-May 2006). The DIAL O3 profiles show many small scale features including filamentary structures associated with intense dynamical events in regions of the Northern Hemisphere subtropical wind jets. One cross-evaluation effort is to determine how well OMI/MLS can detect such O3 variations in the troposphere.

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Title: Comparisons between Aura OMI/MLS and TES tropospheric ozone measurements

Tropospheric O3 mixing ratio derived from Aura Ozone Monitoring Instrument (OMI) total ozone and Microwave Limb Sounder (MLS) stratospheric column ozone residual is compared with tropospheric O3 measurements from Aura Thermal Emission Spectrometer (TES). A unique advantage of these comparisons is that the OMI/MLS and TES satellite measurements are essentially co-located temporally and spatially with only ~7 minute separation in time between them. Inter-comparisons between OMI/MLS and TES focus on different atmospheric air mass regimes extending from the tropics to mid-latitudes where intense cyclogenesis (i.e., baroclinic instabilities/waves) dramatically alters ozone distributions.

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Title: Aura OMI/MLS Measurements of Tropospheric O3 From MJO to El Nino Timescales: Comparisons with MLS Tropospheric H2O and CO

Nearly two years (August 2004-June 2006) of Aura OMI O3 and MLS O3, H2O, and CO daily measurements are evaluated on timescales extending from the 1-2 month Madden-Julian Oscillation (MJO) to Interannual (associated with the recent El Nino in mid-2004 to early 2005). Tropospheric O3 mean mixing ratio derived from OMI total ozone and MLS stratospheric column ozone residual is compared with MLS upper tropospheric H2O and CO mixing ratios between latitudes 60S to 60N. In the tropics on intraseasonal timescales, O3 variability is dominated by the MJO, notably in the region extending eastward from the Indian Ocean into the western Pacific near the dateline. Interannual

changes in tropical O3 show a characteristic east-west dipole about the dateline associated with El Nino. On all timescales, extending from the tropics to midlatitudes, substantial anticorrelations exist between O3 and H2O, and also O3 and CO. In the extratropics, anticorrelations between O3 and H2O, and O3 and CO are attributed largely to lofting/subsidence of tropospheric air mass associated with baroclinic disturbances (cyclogenesis) and stratosphere-troposphere exchange. In SH midlatitudes in summer, interannual anomalies in O3 resemble medium-scale patterns associated with baroclinic waves. Many of the spatial and temporal features observed in tropospheric O3 are reproduced by tropospheric H2O and O3. Even though the recent El Nino in 2004-2005 was weak compared to previous cases, this study illustrates that the OMI and MLS measurements of O3, H2O, and CO are nevertheless capable of delineating important characteristics of this event.

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Title: Continental outflow and intercontinental transport of ozone pollution as determined by O3-CO correlations from TES

We examine the global distribution of TES O3-CO correlations in the middle troposphere in July 2005 and compare to correlations generated with the GEOS-Chem chemical transport model and with ICARTT aircraft observations over the eastern United States (July 2004). The TES data show significant O3-CO correlations downwind of polluted continents, with dO3/dCO enhancement ratios in the range 0.4-1.0 mol mol-1 and consistent with ICARTT data. The GEOS-Chem model reproduces the O3-CO enhancement ratios observed in continental outflow regions, but model correlations are stronger and more extensive. We show that this discrepancy can be explained by spectral measurement errors in the TES data. These errors should be reduced in future data releases due to warm-up of the TES optical bench and improvements in the spectroscopy. We also investigate the transpacific transport of ozone and CO pollution as observed by TES and aircraft during the recent INTEX-B campaign (March-May 2006), and use the GEOS-Chem model to interpret the observed correlations in terms of ozone production and transport in transpacific plumes.

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Title: Ozone and temperature profile comparisons between Aura MLS and NCEP global data assimilation system (GDAS)

In the NCEP global data assimilation system, ozone profile data are from SBUV/2 instruments onboard NOAA satellites (currently NOAA-16, 17 and 18). Unlike MLS, SBUV/2 can not measure ozone in polar night. Besides, SBUV/2 has very coarse vertical resolution in the lower stratosphere and upper troposphere (LS/UT). Aura MLS provides an opportunity to validate ozone analyses of the NCEP GDAS in the polar night and the LS/UT region. Meanwhile, temperature analyses in the NCEP GDAS come from multi-satellites/instruments observations. They provide a good platform to evaluate Aura MLS temperature data. In this study global ozone and temperature profile data are compared between Aura MLS and NCEP GDAS, mainly in the stratosphere. Preliminary results indicate that large differences (up to 45%) in ozone profiles exist in the polar night and the LS/UT region, where

GDAS has no or less accurate ozone observation data input. Elsewhere the MLS and GDAS differences are generally small (~5%). MLS temperature is generally warmer (2-5 K) than the GDAS except for small regions such as tropical upper troposphere.