

EOS project of NASA supports ensemble forecasting of precipitation over the Colorado River Basin. In February of 2002, the Regional Spectral Model (RSM) developed in the National Centers of Environmental Prediction (NCEP) has been installed in the University of Arizona. This study shows an example for West USA with extensive precipitation. The ensemble forecasting system of RSM (hydrostatic version) and MSM (non-hydrostatic version) was used to make 48 and 72-hour precipitation forecasts in the western U.S., in which an extensive snowfall event was successfully predicted. The ensemble forecasting results are evaluated in comparison with ground observation data combining radar verification. In addition, the influence of using high resolution modeling and different forecasting period on the ensemble forecasts is also addressed. Brier skill analysis indicates that the predictability of ensemble forecasting is varied by region, scale, and time.

A51C-0078 0830h POSTER

On the Benefits of Using a Multi Model Ensemble Forecasting System to Improve Forecast Quality

Corinna Moehrlen¹ (+353-21-4903817; c.moehrlen@ucc.ie)

Jess Ulrik Joergensen¹ (+353-21-4903817; jess.joergensen@wanadoo.dk)

Eamon J. McKeogh¹ (+353-21-4902524; e.mckeogh@ucc.ie)

¹Sustainable Energy Research Group, Dept. of Civil and Environmental Eng. University College Cork, Cork 21, Ireland

In this paper we will explore why the use of a limited area multi model ensemble forecasting system can improve the forecasting quality of realtime and climate simulations significantly relative to the best single ensemble member. We will introduce a NWP model, which is build around a kernel. This allows us to implement any number of physics schemes and dynamics schemes in one executable. In the present study we used 50 different model configurations to build one system. The integration time of this system is more than four forecast days pr. wall clock hour on a single PC processor on typical limited area model grids. We will show the capabilities of this system with ensemble members that only differ in their numerical solution of the fast processes vertical diffusion, condensation and dynamics. We will also discuss the possibility to get probabilities from such ensemble systems.

A51C-0079 0830h POSTER

A Look at HIAPER, the new NSF/NCAR Research Aircraft

Krista Laursen¹ (303-497-2003; krista@ucar.edu)

Richard Friesen¹ (rbf@ucar.edu)

David Carlson¹ (dcarlson@ucar.edu)

¹National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-3000, United States

The High-Performance Instrumented Airborne Platform for Environmental Research, or HIAPER, is the new research aircraft presently being developed at the National Center for Atmospheric Research (NCAR) to serve the environmental research needs of the National Science Foundation (NSF) for the next several decades. The basic aircraft – a Gulfstream V (G-V) business jet – has been completed and will shortly undergo extensive modification to prepare it for future deployments in support of a variety of geosciences research missions. This overview presentation on HIAPER will begin with a brief discussion of the project history and an overview of the capabilities of the aircraft and the modifications to be made to the basic airframe.

Next, a summary of the NSF-led HIAPER Community Instrumentation Workshop will be given. This workshop, which was held at NCAR from 4-6 November 2002, provided participants with a forum in which to discuss the types of environmental measurements that should be made with this new airborne platform and to exchange ideas regarding technologies and instrumentation design approaches that are available and should be applied to the development of instrumentation for the aircraft. The workshop findings will be summarized, and specific recommendations regarding the major research areas in which measurements from HIAPER are most needed will be presented. Finally, a brief discussion of possible instrumentation to be considered for deployment on the aircraft will be given.

A51C-0080 0830h POSTER

Engineering and Technical Configuration Aspects of HIAPER, the new NSF/NCAR Research Aircraft

Richard Friesen¹ (303-497-2004; rbf@ucar.edu)

Krista Laursen¹ (krista@ucar.edu)

¹National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-3000, United States

The High-performance Instrumented Airborne Platform for Environmental Research, or HIAPER, is the new research aircraft presently being developed at the National Center for Atmospheric Research (NCAR) to serve the environmental research needs of the National Science Foundation (NSF) for the next several decades. The basic aircraft – a Gulfstream V (G-V) business jet – has been completed and will shortly undergo extensive modification to prepare it for future deployments in support of a variety of geosciences research missions.

This presentation will focus on the many design and engineering considerations that have been made and are yet to come in converting a "green" business jet into a versatile research aircraft to serve the environmental research community. The project teams composed of engineers and scientists from NCAR and the scientific community at large are faced with trade offs involving costs of modifications, airframe structural integrity, aircraft performance (e.g. weight, drag), cabin environment, locations of inlet and sampling ports and FAA certification requirements. Many of the specific engineering specifications and modifications that have been made to date will be presented by way of engineering drawings, graphical depictions and actual photographs of the aircraft structure. Additionally, projected performance data of the modified-for-research aircraft will be presented along with some of the analyses performed to arrive at critical decisions (e.g. CFD airflow analysis). Finally, some of the details of the aircraft "infrastructure" such as signal and power wiring, generic cabin layout and data acquisition will be discussed.

A51C-0081 0830h POSTER

Middle Atmosphere Temperature Trends from Small Rocketsondes

Francis J. Schmidlin (757 824 1618; fjs@osb.wff.nasa.gov)

NASA/Goddard Space Flight Center, NASA Wallops Flight Facility Code 972, Wallops Island, VA 23337, United States

Stratospheric temperature trends derived from United States meteorological rocketsonde measurements obtained between the late 1960's and mid 1990's are examined at the 50-, 40-, and 25-km altitude levels. Although the trends are different at each of the launch locations there is an unequivocal downward slope of about -0.1K to -0.3K per year at many of the launch sites. Distances between launch sites and, in some cases unequal data-record lengths, inhibit determination of trend inter-relationship among the various sites. Although the data only provide a 'snapshot' of atmospheric behavior for the specific location, a particular advantage resulting from using these particular rocketsonde observations is their consistency over time. Thus, using the same rocketsonde type over the data period, i.e., Datasonde, insures a significant reduction of instrument induced anomalies in the temperature profiles. Trends at the 25-km altitude level, approximately 30 hPa, are compared with trends from radiosonde observations. Both rocketsonde and radiosonde measurements were obtained at approximately the same local times and within less than 100 km of each other. Rocketsonde temperatures from the Former Soviet Union are also used and often complement trends from US data.

A51C-0082 0830h POSTER

The Spatial and Temporal Distribution of U.S. Winds and Windpower at 80 m Derived from Measurements

Cristina Lozej Archer¹ (650-497-7340; lozej@stanford.edu)

Mark Zachary Jacobson¹ (650-723-6836; jacobson@cive.stanford.edu)

¹Stanford University, Department of Civil and Environmental Engineering, Stanford, CA 94305, United States

This is a study to quantify U.S. wind power at 80 m (the hub height of large wind turbines) and to investigate whether winds from a network of farms can provide a steady and reliable source of electric power. Data from 1327 surface stations and 87 soundings in the United States for the year 2000 were used. Several methods were tested to extrapolate 10-m wind measurements to 80 m. The most accurate, a least-squares fit based on twice-a-day wind profiles from the soundings, resulted in 80-m wind speeds that are, on average, 1.3-1.7 m/s faster than those obtained from the

most common methods previously used to obtain elevated data for U.S. windpower maps, a logarithmic law and a power law, both with constant coefficients. The implication is that U.S. windpower at 80 m is enormous and much greater than previously thought. It was found that 25.2 percent of all stations (and 44.6 percent of all coastal/offshore stations) are characterized by mean annual speeds ≥ 6.9 m/s at 80 m, implying that the winds over possibly one quarter of the U.S. are strong enough to provide electric power at a direct cost equal to that of a new natural gas or coal power plant. The greatest previously uncharted reservoir of windpower in the continental U.S. is offshore and near shore along the southeastern and southern coasts. The other great reservoirs, previously charted, are the north- and south-central regions. The five states with the highest percentage of stations with annual mean 80-m winds ≥ 6.9 m/s were Oklahoma, South Dakota, North Dakota, Kansas, and Nebraska. Other findings are (1) monthly and annual mean wind speed (and wind power) peaks in the afternoon, when electricity demand is usually high; (2) winds are Rayleigh in nature, and actual wind power at any hour of the day is close to Rayleigh wind power; (3) the standard deviation of the wind speed averaged over multiple locations is less than that at any individual location; (4) when multiple wind sites are considered, the probability of no wind power production at a given instant is substantially reduced in comparison to when one wind site is considered. In sum, a network of wind farms in locations with high annual mean wind speeds can provide a reliable and abundant source of electric power.

URL: <http://fluid.stanford.edu/~lozej/winds/winds.html>

A51D MCC: 102 Friday 0830h

Transport and Effects of Anthropogenic Pollutants: Trace-P I (joint with GC)

Presiding: J Crawford, NASA Langley Research Center; D Jacob, Harvard University

A51D-01 0830h

The NASA/GTE/TRACE-P Mission: Design and Execution

Daniel J. Jacob¹ (617-495-1794; dj@io.harvard.edu); J. H. Crawford²; H. E. Fuelberg³; V. E. Connors²; M. M. Kiehl²; R. J. Bendura²; J. L. Raper²

¹Harvard University Division of Engineering and Applied Sciences, 29 Oxford Street, Cambridge, MA 02138, United States

²NASA/Langley Research Center, Atmospheric Sciences, Hampton, VA 23681, United States

³Florida State University, 2525 Pottsdamer Street, Tallahassee, FL 32306, United States

The Transport and Chemical Evolution over the Pacific (TRACE-P) aircraft mission was conducted in February-April 2001 over the western Pacific by the NASA Global Tropospheric Experiment (GTE). It had two objectives: (1) to determine the chemical composition of the Asian outflow over the western Pacific in order to understand and quantify the export of chemically and radiatively important gases and aerosols, and their precursors, from the Asian continent; (2) to determine the chemical evolution of the Asian outflow and to understand the ensemble of processes that control this evolution. TRACE-P used two aircraft, a DC-8 and a P-3B, operating out of Hong Kong and Japan. Measurements on both aircraft included ozone and its precursors, aerosols and their precursors, and long-lived greenhouse gases. Flights were designed to capture the ensemble of major source regions and meteorological pathways contributing to the Asian outflow. Chemical forecasts from five 3-D models were used to supplement meteorological forecasts and to optimize the value of the TRACE-P data set for testing these models. Linkages were made with concurrent measurements from other platforms, including the ACE-Asia aircraft mission and satellites, in order to produce an integrated data set directed at the TRACE-P objectives. Several validation profiles were conducted for the MOPITT carbon monoxide instrument aboard the Terra satellite. Interpretation of the TRACE-P data set is now providing new insights into the nature and magnitude of Asian sources and their contributions to global atmospheric composition.

A51D-02 0845h

Atmospheric Transport During the Transport and Chemical Evolution Over the Pacific (TRACE-P) Experiment

Henry E. Fuelberg¹ (850-644-6466; fuelberg@met.fsu.edu); Christopher M. Kiley¹ (ckiley@met.fsu.edu); John R. Hannan¹ (jhannan@met.fsu.edu); David J. Westberg² (d.j.westberg@larc.nasa.gov); Melody A. Avery³ (m.a.avery@larc.nasa.gov); Reginald E. Newell⁴ (RENewell@mit.edu)

¹Florida State University, Department of Meteorology, Tallahassee, FL 32306-4520, United States

²Science Applications International Corp., NASA Langley Research Center, Hampton, VA 23669, United States

³NASA Langley Research Center, Mail Stop 483, Hampton, VA 23665, United States

⁴Massachusetts Institute of Technology, Dept. of Earth, Atmospheric, and Planetary Sciences, Cambridge, MA 02139, United States

Atmospheric transport over the Pacific Basin is described during NASA's Transport and Chemical Evolution Over the Pacific Experiment (TRACE-P) that was conducted between February - April 2001. Mean flow patterns during the two halves of TRACE-P are discussed. The Siberian anticyclone and transient middle latitude cyclones that form near eastern Asia are important circulation features. Five-day backward trajectories from the various flight tracks show that air sampled by the aircraft had been transported from a variety of locations. Some parcels remained over the tropical western North Pacific during the entire period, while other important origins were Southeast Asia, Africa, and central Asia. Patterns of satellite-derived precipitation and lightning are described. TRACE-P occurs during a neutral to weak La Nina period of relatively cold sea surface temperatures in the tropical Pacific. Compared to climatology, the TRACE-P period exhibits deep convection located west of its typical position; however, tropospheric flow patterns do not exhibit a strong La Nina signal. Circulation patterns during TRACE-P are compared with those during the PEM WEST B mission that occurred during February - March 1994. Meteorological conditions during these missions are found to be very similar.

A51D-03 0900h

TRACE-P Informal Instrument Intercomparison

Fred L. Eisele^{1,2} (303-497-1483; eisele@ucar.edu); L. Mauldin¹; C. Cantrell¹; E. Apel¹; A. Fried¹; R. Shetter¹; F. Flocke¹; A. Weinheimer¹; M. Avery³; S. Vay³; G. Sachse³; H. Singh⁹; W. Brune⁴; A. Bandy⁵; B. Heikes⁶; Y. Kondo⁷; D. Riemer⁸; S. Sandholm²; D. Tan²; R. Talbot¹⁰; J. Dibb¹⁰

¹National Center for Atmospheric Research, 1850 Table Mesa Drive, Boulder, CO 80305, United States

²Georgia Institute of Technology, Earth and Atmospheric Sciences 221 Bobby Dod Way, Atlanta, GA 30332, United States

³NASA Langley Research Center, Atmospheric Study Branch Mail Stop 483, Hampton, VA 23681, United States

⁴Penn State University, Department of Meteorology 503 Walker Building, University Park, PA 16802, United States

⁵Drexel University, Department of Chemistry 32nd and Chestnut Street, Philadelphia, PA 19104, United States

⁶University of Rhode Island, Graduate School of Oceanography, Narragansett, RI 02882, United States

⁷University of Tokyo, Dept. Earth Planetary Sci. Hongo 7-3-1, Tokyo 113-0033, Japan

⁸University of Miami, Atmospheric Chemistry, Miami, FL 33149, United States

⁹NASA Ames Research Center, Earth Science Division, Moffett Field, CA 94035, United States

¹⁰University of New Hampshire, Inst for Study of Earth, Oceans and Space, Durham, NH 03824, United States

The NASA DC-8 and P-3B aircraft were flown along side of each other in close proximity on 3 different occasions during the TRACE-P mission. The duration of these adjacent flights, during which instruments on the two aircraft could be compared, ranged from about 25 to 78 minutes. High time resolution measurements such as O₃, CO, CH₄, and CO₂ present on the two aircraft

both showed good agreement between aircraft and provided a measure of second or subsecond time lags between aircraft as each entered similar air mass structures. Dozens of measurements were intercompared, and as expected in general measurements of more abundant, longer lived compounds agreed better than less abundant, shorter-lived compounds, though this was not always the case. Measurements of O₃, CO, CO₂, CH₄ agreed extremely well. Measurements of NO, PAN and to a lesser extent HNO₃ also agreed quite well. Many of the other measurements also agreed within the combined limits of errors of the two measurements particular at high concentrations but there were also some cases where discrepancies were quite significant.

Over all the intercomparison was highly successful pointing out potential problems and providing a means to evaluate differences in measurement/model discrepancies on the two aircraft. While intercomparisons conducted during a mission are limited in extent, they provide the unique opportunity to intercompare the actual instrument and inlet configurations used on the mission at various time periods throughout the study. This type of intercomparison can in some cases also help identify erroneous instrument operation just prior to a mission allowing corrective action early in the study.

A51D-04 0915h

Large-Scale Ozone and Aerosol Distributions, Air Mass Characteristics, and Ozone Fluxes Observed Over Springtime Western Pacific Ocean During TRACE-P

Edward V. Browell¹ (757-864-1273; e.v.browell@larc.nasa.gov); Carolyn F. Butler² (c.f.butler@larc.nasa.gov); Marta A. Fenn² (m.a.fenn@larc.nasa.gov); William B. Grant¹ (w.b.grant@larc.nasa.gov); Vincent G. Brackett² (v.g.brackett@larc.nasa.gov); Johnathan W. Hair¹ (j.w.hair@larc.nasa.gov); Melody A. Avery¹ (m.a.avery@larc.nasa.gov); Reginald E. Newell³ (renewell@mit.edu); Yuanlong Hu³ (ylhu@mit.edu); Henry E. Fuelberg⁴ (fuelberg@met.fsu.edu); Daniel J. Jacob⁵ (djj@io.harvard.edu)

¹NASA Langley Research Center, Atmospheric Sciences, MS-401A, Hampton, VA 23681, United States

²SAIC/NASA LaRC, Atmospheric Sciences, Hampton, VA 23681, United States

³Massachusetts Institute of Technology, Dept. of Earth, Atmospheres and Planetary Sciences, Cambridge, MA 02139, United States

⁴Florida State University, Dept. of Meteorology, Tallahassee, FL 32306, United States

⁵Harvard University, Dept. of Earth and Planetary Sciences, Cambridge, MA 02138, United States

Large-scale measurements of ozone (O₃) and aerosol distributions were made from the NASA DC-8 aircraft during the Transport and Chemical Evolution over the Pacific (TRACE-P) field experiment conducted in February-April 2001. Remote measurements were made with an airborne lidar to provide O₃ and multiple-wavelength aerosol backscatter profiles from near the surface to above the tropopause along the flight track. Aerosol depolarization measurements were also made for the detection of desert dust aerosols. In situ measurements of O₃, aerosols, and a wide range of trace gases were made onboard the DC-8. Meteorological analyses of the potential vorticity (PV) distributions along the flight track were used to indicate the fraction of observed O₃ that could be attributed to stratosphere-troposphere exchange (STE). Five-day backward trajectories were used to indicate the possible origin of observed air masses. The results from TRACE-P show a wide range of air mass characteristics and processes, and examples of these observations are discussed in this paper.

Ozone and aerosol scattering ratio distributions from each TRACE-P flight were binned and averaged by latitude and longitude in different geographic regions over the Pacific. The average latitudinal O₃ and aerosol scattering ratio distributions were then derived from all flights west of 150°E. These distributions show the latitude and altitude dependence of different dynamical and chemical processes in determining the atmospheric composition over the western Pacific. These results are compared to those from the Pacific Exploratory Mission-West B (PEM-West B) field experiment, which took place in February-March 1994. TRACE-P showed an increase in the average latitudinal distributions of both O₃ and aerosols compared to PEM-West B. This correlation generally indicates that much of the O₃ increase was due to photochemical production.

Ozone, aerosol, and PV levels observed on each TRACE-P mission were also used to identify nine air mass types and quantify their frequency of occurrence as a function of altitude. This paper discusses the characteristics of the different air mass types encountered during TRACE-P and compares them to PEM-West B.

There were only small differences between the average observed frequency of the different air mass types in the region of 14-25°N but from 25-46°N there was a large increase in frequency of air masses associated with photochemically produced O₃ with no significant increase in air masses associated with STE. The first estimates of the easterly tropospheric flux of O₃ were also obtained by combining the large-scale O₃ cross sections from each flight with the meteorological wind analyses. The average latitudinal tropospheric O₃ flux was found to peak at 32°N, and the total average O₃ flux between 14-46°N for TRACE-P was found to be 5.1 Tg/day. The average latitudinal O₃ flux distributions for each air mass type were determined, and they are also discussed in this paper.

A51D-05 0930h

A Principal Component Analysis of TRACE-P Whole Air Data (Nonmethane Hydrocarbons, Halocarbons, Alkyl Nitrates and Sulfur Compounds)

Isobel J Simpson¹ (isimpson@uci.edu)

Yunsoo Choi¹ (yunsoochoi@hotmail.com)

Donald R Blake¹ (drblake@uci.edu)

F Sherwood Rowland¹ (rowland@uci.edu)

¹University of California-Irvine, Department of Chemistry, 516 Rowland Hall, Irvine, CA 92697-2025, United States

Principal Component Analysis (PCA) is a multivariate statistical technique that can be used to identify major pollution sources and their emission composition from within a large ambient measurement data set. Here we apply PCA to a regional whole air data set collected during the airborne Transport and Chemical Evolution over the Pacific (TRACE-P) field campaign (February-April, 2001). The data set comprises a matrix of 3458 samples by 47 compounds (nonmethane hydrocarbons, halocarbons, alkyl nitrates, and sulfur compounds), collected at altitudes between 150 m and 12 km. Between 25-46 N latitude, industrial tracers such as the CFC replacement compounds (HCFCs) dominated the variance within the data set. Photochemically processed urban air and air influenced by emissions from the People's Republic of China also featured strongly. Further south between 7-25 N, processed urban air dominated the observed variance. Tracers indicative of automobile exhaust and gasoline evaporation were also evident in the Principal Component Analysis.

A51D-06 0945h

A Comparison of Photochemical Environments in the NW Pacific as Observed during NASAs PEM-West B (1994) and TRACE-P (2001) Airborne Field Studies

Douglas D Davis¹ (404-894-9565; dd16@prism.gatech.edu)

Gao Chen¹

James H Crawford²

TRACE-P Science Team

¹Georgia Institute of Technology, 221 Bobby Dodd Way, Atlanta, GA 30332, United States

²NASA Langley Research Center, Mail Stop 483, Hampton, VA 23681, United States

Predictions of Pacific Rim emissions of trace gases in the pre-1990 time frame suggested that increases as high 5% per year might occur during the decade of the 90's. More recently, however, these earlier evaluations have been downgraded such that estimated 2001 levels of many species are now expected to be not all that different from those in the early 90's. In this context, NASAs GTE (Global Tropospheric Experiment) program has made it possible to test these conclusions as a result of its promoting both the 1994 PEM-West B and the 2001 TRACE-P field studies. Both of these programs were launched in the early spring and both were focused on examining the outflow from Asian Pacific Rim countries into the North Pacific. Although the latter program was far better instrumented than its predecessor and also included a two aircraft sampling strategy, the critical photochemical species were recorded during both studies. To be presented are observational and modeling results derived from a comparison of these two field programs. A primary focus of this effort has been the intensity of photochemistry in the NW Pacific. Both O₃ precursor levels as well as O₃ photochemical trends themselves have been examined. The latter have also been compared with the long term trends derived from an analysis of several ozonesonde data sets recorded in this region. Collectively, the results have revealed a systematic shift in

O₃ levels between 1994 and 2001. The reasons for this shift will be discussed.

A51D-07 1020h

Variability of Atmospheric CO₂ over the western North Pacific: Influence of Asian outflow during March-April 2001

Stephanie A. Vay¹ (1-757-864-1574; s.a.vay@larc.nasa.gov); Jung-Hun Woo² (woojh21@cgrrer.uiowa.edu); Bruce E. Anderson¹ (b.e.anderson@larc.nasa.gov); Kenneth Lee Thornhill³ (k.l.thornhill@larc.nasa.gov); Chris Kiley⁴ (ckiley@met.fsu.edu); Melody A. Avery¹ (m.a.avery@larc.nasa.gov); Glen W. Sachse¹ (g.w.sachse@larc.nasa.gov); Donald R. Blake⁵ (dblake@orion.oac.uci.edu); David G. Streets⁶ (dstreets@anl.gov); Scott R. Nolf⁷ (snolf@csc.com)

¹NASA Langley Research Center, MS 483, Hampton, VA 23681, United States

²Center for Global and Regional Environmental Research, 252 Iowa Advanced Technology Laboratory, University of Iowa, Iowa City, IA 52242, United States

³Science Applications International Corporation, 1 Enterprise Parkway, Suite 300, Hampton, VA 23666, United States

⁴Florida State University, Department of Meteorology, Tallahassee, FL 32306

⁵University of California, Irvine, Department of Chemistry, Irvine, CA 92697, United States

⁶Argonne National Laboratory, 9700 South Cass Avenue, DIS/900, Argonne, IL 60439, United States

⁷Computer Sciences Corporation, 21 Enterprise Parkway, Suite 150, Hampton, VA 23666, United States

We report here tropospheric CO₂ measurements made as part of the airborne component of NASA's Transport and Chemical Evolution over the Pacific (TRACE-P) Mission during March and April in 2001. CO₂ mixing ratios, sampled in the subtropics (23.5-45.5° N) west of 150° E, exhibited a decreasing trend with height (0.5-12 km), were highly correlated with latitude showing a distinct north to south gradient, and peaked between 35-40° N within the planetary boundary layer. Near the Asian continent, discrete plumes encountered below 4 km contained up to 393.6 ppmv CO₂ and were augmented with the combustion and industrial tracers CO, C₂H₆, C₃H₈, CH₃Cl, C₂Cl₄, and C₆H₆. A chemically based air mass classification scheme using the combustion products CO and C₂H₂ as tracers of continental source emissions was employed in this analysis. Results show an excellent positive correlation for CO₂ ($r^2=0.98$) with respect to this ratio in the lower to mid free troposphere (4-8 km) providing evidence of continental outflow. South of the Tropic of Cancer, mean and median CO₂ values derived from samples obtained below 8 km are less than those calculated for the subtropics. However, within the upper troposphere (UT) of both regions, similar values were determined and enhancements in combustion-derived species in the 8-12 km altitude range were observed. The relationship revealed between CO₂ and the C₂H₂/CO ratio, particularly for the tropics, suggests recent inputs from the surface to the UT. In order to elucidate the processes determining the variations of CO₂ in the Asian Pacific rim region during TRACE-P, a CO₂ emissions data base developed for Asia was examined in conjunction with the chemistry and 5 day backward trajectories in an attempt to link CO₂ enhancements observed in pollution plumes to source regions. From these data acquired downwind of the Asian continent when CO₂ concentrations at the surface were approaching their seasonal maximum, we estimate a net export flux on the order of 20 Tg C day⁻¹ attributable to both anthropogenic emissions and the respiration of the terrestrial biosphere, animals, and humans.

A51D-08 1035h

Constraints on Asian Carbon Fluxes Using CO₂/CO Correlations from TRACE-P Aircraft Data

Parvatha Suntharalingam¹ (1-617-496-7446; pns@sol.harvard.edu); Daniel J Jacob¹ (djj@sol.harvard.edu); David Streets² (dstreets@anl.gov); Paul Palmer¹ (pip@io.harvard.edu); Yaping Xiao¹ (xyp@io.harvard.edu); Robert Yantosca¹ (bmy@io.harvard.edu); Stephanie Vay³ (s.a.vay@larc.nasa.gov); Glen Sachse³ (g.w.sachse@larc.nasa.gov); Charles Harward⁴ (c.n.harward@larc.nasa.gov)

¹Harvard University, Department of Earth and Planetary Sciences Pierce Hall 29, Oxford Street, Cambridge, MA 02138, United States

²Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439, United States

³NASA Langley Research Center, 100 NASA Road, Hampton, VA 23681, United States

⁴SAIC, NASA Langley Research Center 100 NASA Road, Hampton, VA 23681, United States

Observed correlations between CO₂ and chemical tracers such as CO offer promising new constraints on regional carbon fluxes. In this analysis we investigate the potential of measured CO₂/CO correlations, from the NASA-GTE TRACE-P aircraft campaign, to improve quantification of Asian CO₂ emissions. Strong correlations with different CO₂/CO slopes are apparent in the TRACE-P data and indicate outflow from distinct source regions.

We present an analysis of this data in conjunction with forward simulations for CO₂ and CO from the GEOS-CHEM 3-D tracer transport model. Use of the 3-D model enables us to identify the respective influences of the separate source regions on the observed CO₂/CO slopes and thus evaluate the imposed CO₂/CO emission ratios in the model.

A51D-09 1050h

Dynamics and Transport of Sulfur Dioxide Over the Western Pacific Ocean During Trace-P

Fang Huang Tu¹ (215-895-1576; fhtu@drexel.edu);

Donald C. Thornton¹ (215-895-2657;

dct@drexel.edu); Alan R. Bandy¹ (215-895-2640;

bandyar@drexel.edu); Mi-Sug Kim¹ (215-895-2656;

Misug.Kim@drexel.edu); Gregory

R. Carmichael² (319-335-1399;

gregory-carmichael@uiowa.edu); Youhua Tang²

¹Drexel University, Department of Chemistry 3141 Chestnut ST., Philadelphia, PA 19104, United States

²University of Iowa, CGRER 424 IATL, Iowa City, IA 52242, United States

High time resolution (>1 Hz) sulfur dioxide (SO₂) measurements were obtained using an atmospheric pressure mass spectrometer with isotopically labeled internal standard on the NASA Wallops P-3B during the NASA Trace-P field experiment. The high time resolution for SO₂ allowed a view into the dynamics of SO₂ transport, including the effects of clouds.

Two missions along 124.5° E from the vicinity of Taiwan to the northern Yellow Sea near the Korean peninsula were flown on consecutive days with quite different weather conditions. During the 17 Mar 02 flight, there was low level stratus deck off the coast of China overlaid with several cloud layers. The following day's flight was in clear air that had filled in behind a front to the north that had moved eastward during the night. Although the winds on both flights were westerly to northwesterly, the SO₂ concentrations were markedly different in vertical and horizontal distributions.

Together with turbulence measurements and other high rate data on the P-3B, we have assessed how the differences in the SO₂ distributions may have been caused by cloud processing and the limitations to transport by atmospheric dynamics. When compared to 3-D model results (Carmichael et al.) of SO₂ along the flight track, the in situ SO₂ data showed that the model poorly represented the SO₂ distribution along the flight track for the cloudy day while the model gave a reasonably good representation of the in situ data during the clear air flight. Even on the clear day flight the model overestimated the SO₂ concentrations just above the well mixed layer within the boundary layer.

A51D-10 1105h

Export of Sulfur and Nitrogen Compounds From the East Asia Region in Spring

Makoto Koike¹ (81-3-5841-4595;

koike@eps.s.u-tokyo.ac.jp); Yutaka Kondo²;

Kazuyuki Kita³; Nobuyuki Takegawa²; Yukio

Masui¹; Rodney Weber⁴; Yin-Nan Lee⁵; Yilin

Ma⁴; Donald Thornton⁶; Alan Bandy⁶; Glen

Sachse⁷; Melody Avery⁷; Stephanie Vay⁷; David

Streets⁸; Yuzo Miyazaki²; Hibiki Ikeda²

¹Department of Earth and Planetary Sciences, University of Tokyo, Hongo 7-3-1, Bunkyo-ku, Tokyo 113-0033, Japan

²Research Center for Advanced Science and Technology, University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8904, Japan

³Department of Environmental Sciences, Ibaraki University, 2-1-1 Bunkyo, Mito, Ibaraki, Ibaraki 310-8512, Japan

⁴Department of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Atlanta, GA 30332-0340, United States

⁵Brookhaven National Laboratory, Upton, Upton 11973-5000, United States

⁶Drexel University, Philadelphia, Philadelphia, PA 19104, United States

⁷NASA Langley Research Center, Hampton, Hampton, VA 23681-0001, United States

⁸Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439, United States

Measurements of gaseous and particulate compounds of sulfur and reactive nitrogen species as well as other chemical species were made over the western Pacific during the NASA/TRACE-P experiment conducted between February and April 2001. Emission ratios of SO₂, NO_x, CO, and CO₂ over East Asian countries were compared with observed ratios of increases of these species to study the transport efficiency of anthropogenic sulfur and reactive nitrogen compounds. The result obtained in this study suggests that only 20-40% and 10% of SO₂ emitted over the continent was exported out into the western Pacific in an altitude range of 0-2 and 4-7 km, respectively. Similarly, a transport efficiency of reactive nitrogen compounds was suggested to be 10-35% and 10-20% at 0-2 and 4-7 km ranges. Only 2-4% and 0.5-1% of NO_x emitted in the East Asia region was suggested to be transported in the form of NO_x in these altitude ranges.

A51D-11 1120h

Effects of Biomass Burning on the Distributions of Trace Species Over the Western Pacific Ocean

Yutaka Kondo¹ (81-3-5452-5145;

kondo@atmos.rcast.u-tokyo.ac.jp); Makoto Koike²

(81-3-5841-4595; koike@eps.s.u-tokyo.ac.jp); Yu

Morino¹ (81-3-5452-5146;

morino@atmos.rcast.u-tokyo.ac.jp); Nobuyuki

Takegawa¹ (81-3-5452-5144;

takegawa@atmos.rcast.u-tokyo.ac.jp); Kazuyuki

Kita³ (81-29-228-8400; kita@env.sci.ibaraki.ac.jp);

Yuzo Miyazaki¹ (81-3-5452-5147;

yuzom@atmos.rcast.u-tokyo.ac.jp)

¹Research Center for Advanced Science and Technology, University of Tokyo, 4-6-1 Komaba, Meguro-ku, Tokyo 153-8904, Japan

²Department of Earth and Planetary Science, University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

³Department of Environmental Sciences, Faculty of Science, Ibaraki University, 2-1-1 Bunkyo, Mito 310-8512, Japan

Biomass burning activity was high over Southeast Asia in March 2001 during TRACE-P. Air masses impacted by biomass burning were frequently transported from the boundary layer to the free troposphere by convection over Southeast Asia. These plumes were transported horizontally to the western Pacific Ocean above 2 km along the prevailing westerly flow. We assessed the effects of biomass burning on O₃, its precursors (NO_x, NO_y, CO, NMHCs), and aerosols using the chemical data obtained on board the P-3B and DC-8 aircraft during TRACE-P. CH₃Cl, C₂Cl₄, HCN, and CH₃CN were used to distinguish the biomass burning plumes from urban pollution plumes. Increases in the mixing ratios of these species against the background values were largest at 2-4 km. The previously reported emission ratios of CH₃Cl, NMHCs, NO_y, SO₂, and NH₃ relative to CO were compared with the observed correlations of these species with CO to investigate the chemical processes in the biomass burning plumes.

A51D-12 1135h

Inverting for Asian Emissions of Carbon Monoxide Using Aircraft Observations During TRACE-P

Paul I Palmer¹ (pip@io.harvard.edu); Daniel J Jacob¹; Dylan B Jones¹; Colette L Heald¹; Jennifer A Logan¹; Glen Sachse²; David G Streets³

¹Division of Engineering and Applied Sciences, Harvard University, 29 Oxford Street, Cambridge, MA 02138, United States

²NASA, NASA Langley Research Center, Hampton, VA 23681, United States

³Argonne National Laboratory, 9700 South Cass Avenue, Argonne, IL 60439, United States

A main mission objective of TRACE-P was to quantify the export of chemically and radiatively important gases from Asia. Here we present a GEOS-CHEM global 3d model simulation of the aircraft measurements of CO taken during TRACE-P, and we apply an inverse model analysis to this simulation to improve estimates of Asian emissions. The simulation starts from our best prior knowledge of CO sources, including a detailed inventory of Asian emissions for fossil fuels, bio-fuels, and biomass burning. The daily spatio-temporal variability of the emissions from biomass burning is constrained by satellite observations of fire activity. The inverse model computes the best estimate of CO emissions that is consistent with both the aircraft observations and the prior information, given their respective uncertainties. Results indicate in particular larger-than-expected emissions of anthropogenic CO from China.

URL: <http://www-as.harvard.edu/chemistry/trop/tracep/>

A51D-13 1150h

A Comparison of Several Chemical Transport Models With Aircraft Derived Plumes of CO From East Asia During the Spring 2001 NASA/TRACE-P Mission

Christopher M Kiley¹ (850-644-6989;

ckiley@met.fsu.edu); Henry E Fuelberg¹ (fuelberg@met.fsu.edu); Daniel J Jacob² (djj@io.harvard.edu); Paul I Palmer² (pip@io.harvard.edu); Kenneth E Pickering³ (pickering@atmos.umd.edu); Dale John Allen⁴ (allen@atmos.umd.edu); Gregory R Carmichael⁵ (gcarmich@caen.uiowa.edu); T. Duncan Fairlie⁶ (tdf@io.harvard.edu); Celine Mari⁷ (marc@aero.obs-mip.fr); R. Bradley Pierce⁸ (r.b.pierce@larc.nasa.gov); Oliver Wild⁹ (oliver@jamstec.go.jp); Jennifer Logan¹⁰ (jal@io.harvard.edu); David G. Streets¹¹ (dstreets@anl.gov); Youhua Tang⁵ (ytang@cegre.uiowa.edu)

¹Department of Meteorology, Florida State University, Tallahassee, Florida State University Dept. of Meteorology 404 Love Building, Tallahassee, FL 32306-4520, United States

²Department of Earth and Planetary Sciences and Division of Engineering and Applied Sciences, Harvard University, Cambridge, MA., Pierce Hall 29 Oxford St. Harvard University, Cambridge, MA 02138, United States

³Joint Center for Earth System Science, University of Maryland, NASA Goddard Space Flight Center, Greenbelt., Dept. of Meteorology University of Maryland, College Park, MA 20742, United States

⁴Department of Meteorology, University of Maryland, College Park., Dept. of Meteorology University of Maryland, College Park, MD 20742, United States

⁵Center for Global and Regional Environmental Research and Department of Chemical and Biochemical Engineering, University of Iowa, Iowa City., Dept. of Chemical Biochemical Engineering University of Iowa, Iowa City, IA 52242, United States

⁶Department of Earth and Planetary Sciences and Division of Engineering and Applied Sciences, Harvard University, Cambridge, MA. NASA Langley Research Center, Hampton, VA., Pierce Hall 29 Oxford St. Harvard University, Cambridge, MA 02138, United States

⁷Laboratoire d'Aerologie, UMR CNRS/Universite Paul Sabatier, Toulouse, France., Laboratoire d'Aerologie (UMR CNRS/UPS 5560) OMP 14, avenue Edouard Belin, Toulouse 31400, France

⁸NASA Langley Research Center, Hampton, VA., MS 401B NASA Langley Research Center, Hampton, VA 23188, United States

⁹Frontier Research System for Global Change, Tokyo., 3173-25 Show-machi, Kanazawa-ku, Yokohama, Kanagawa 236-001, Japan

¹⁰Department of Earth and Planetary Sciences, Harvard University, Cambridge, MA., Pierce Hall 29 Oxford St. Harvard University, Cambridge, MA 02138, United States

¹¹Argonne National Laboratory, Argonne, IL., 9700 S. Cass Ave., Argonne, IL 60439, United States

A major goal of NASAs TRANsport and Chemical Evolution over the Pacific (TRACE-P) aircraft mission was to determine how three-dimensional chemical tracer simulations compare among themselves and observations. We compare seven three-dimensional chemical transport models, each with its unique domain, resolution, meteorological fields, and approaches for chemical processes. We investigate how the different chemical transport models simulate the outflow of carbon

monoxide from East Asia during TRACE-P. The study examines major plumes/laminae of CO, focusing on their concentrations, as well as their horizontal placements, altitudes, and depths. We focus on how differing parameterizations of boundary layer processes and deep convection affect each models simulation of CO. We also examine the simulated CO patterns in areas of fronts to see their effect on models results. Finally, we compare simulated CO against corresponding DC-8 aircraft derived measurements for each TRACE-P flight. This paper provides a survey of the CO differences between models. It identifies circumstances where models are consistent or inconsistent with observations and with each other.

A51E MCC: 125 Friday 0830h

Aerosol, Cloud, and Tropospheric Chemistry I

Presiding: M C Barth, National Center for Atmospheric Research; P Y Chuang, University of California, Santa Cruz

A51E-01 0830h INVITED

Kinetics of Heterogeneous Ice Nucleation on Mineral Dusts

Scott T Martin¹ (smartin@deas.harvard.edu)

Hui-Ming Hung¹ (hnhung@deas.harvard.edu)

Adam Malinowski¹ (adma@deas.harvard.edu)

¹Harvard University, 29 Oxford St., Pierce Hall, Cambridge, MA 02138

Ice freezing of aqueous ammonium sulfate particles containing hematite or corundum mineral dust cores is studied by aerosol flow tube infrared spectroscopy (AFT-IR). The cores induce freezing heterogeneously at temperatures warmer than homogeneous nucleation. Heterogeneous nucleation rates (j) varying from 10^2 to 10^6 $\text{cm}^{-2} \text{s}^{-1}$ are reported, depending on the diameter of the hematite or corundum core (50 to 250 nm), temperature, and aqueous mole fraction composition. Contact parameters for ice against hematite or corundum equal 0.0. The temperature-dependence (215 to 235 K) of the surface tension of ice against aqueous ammonium sulfate solutions has a positive slope for pure water and becomes progressively negative as the ammonium sulfate content increases. These results quantify an important role for mineral dusts as initiators of cirrus cloud formation by heterogeneous nucleation.

A51E-02 0850h

HNO₃ Condensation on Ice in the Upper Troposphere: Comparing Laboratory, Atmospheric and Theoretical Data

Brandy Gamblin^{1,2} (gamblin@colorado.edu); Owen B Toon^{2,3}; Yutaka Kondo⁴; Hitoshi Irie⁵; Margaret A Tolbert^{1,6}; Paula K Hudson^{1,6}; Albert A Viggiano⁷; Donald E Hunton⁷; John O Ballenthin⁷; Thomas M Miller⁷; Bruce E Anderson⁸

¹Department of Chemistry and Biochemistry, Campus Box 215, University of Colorado, Boulder, CO 80309-0215, United States

²Laboratory for Atmospheric and Space Physics, Campus Box 392, University of Colorado, Boulder, CO 80309-0392, United States

³Program in Atmospheric and Oceanic Sciences, Campus Box 311, University of Colorado, Boulder, CO 80309-7167, United States

⁴Research Center for Advanced Science and Technology, University of Tokyo 4-6-1 Komaba, Meguro, Tokyo 153-8904, Japan

⁵National Institute for Environmental Studies, Satellite Remote Sensing Research Team 16-2, Onogawa, Tsukuba, Ibaraki 305-0053, Japan

⁶Cooperative Institute for Research in Environmental Sciences (CIRES), Campus Box 216, University of Colorado, Boulder, CO 80309-0216, United States

⁷Air Force Research Laboratory, 29 Randolph Road, Hanscom AFB, MA 01731-3010, United States

⁸Langley Research Center, Mail Stop 483, National Aeronautics and Space Administration, Hampton, VA 23681-2199, United States

Recent observations suggest nitric acid will condense significantly on ice particles in the upper troposphere. However, the importance of this process, and the role it plays in the upper tropospheric NO_y budget are not clear. In a modeling study, Lawrence and Crutzen [1998] suggested that nitric acid condensation on settling ice particles would be a significant loss mechanism for nitric acid in the upper troposphere. While the Weinheimer et al., [1998] field study found significant NO_y on ice, Meilinger et al., [1999] found very little HNO₃ present on ice clouds.

In order to understand the efficacy of HNO₃ removal via condensation on ice, we analyzed new data taken during the SOLVE campaign [Kondo et al., 2003] and then compared this data to theoretical values of nitric acid condensation on ice based upon recent equilibrium laboratory data [Hudson et al., 2002]. Our analysis of the Kondo et al. data showed for the first time extensive evidence of significant HNO₃ condensation on upper tropospheric ice particles and proved that a substantial fraction of total NO_y can be present on the ice crystals. A surprising aspect of the data is that in regions of constant temperature, constant nitric acid concentration and constant surface area, surface coverage varied by orders of magnitude.

This spread in surface coverage occurs because HNO₃ condensation on cirrus ice particles is controlled by the kinetics of mass transfer and can require days to come to equilibrium with the surrounding nitric acid vapor. During this time, several microphysical processes such as condensation, evaporation, coagulation, freezing, melting and nucleation are possible which can significantly alter the concentration and properties of particles in the cloud and directly affect HNO₃ vapor concentrations. Due to the complex nature of these processes a cloud microphysical model will be used to simulate the NO_y budget of the cloudy upper troposphere and to help interpret the new field and laboratory data.

Hudson, P., HNO₃ uptake on ice: implications for cirrus clouds, in preparation, 2002.

Kondo, Y., Uptake of nitric acid on cirrus cloud particles in the upper troposphere and lowermost stratosphere, in preparation, 2003.

Meilinger, S., HNO₃ partitioning in cirrus clouds, GEOPHYS. RES. LETT., 26 (14): 2207-2210, 1999.

Lawrence, M., P. Crutzen, The impact of cloud particle gravitational settling on soluble trace gas distributions, TELLUS, B 50 (3): 263-289, 1998.

Weinheimer, A., Uptake of NO_y on wave-cloud ice particles, GEOPHYS. RES. LETT., 25 (10): 1725-1728, 1998.

A51E-03 0905h

The SMOCC experiment: Smoke Aerosols, Clouds, Rainfall and Climate: Aerosols from Biomass Burning Perturb Global and Regional Climate

Paulo Artaxo¹ (artaxo@if.usp.br); Jose Vanderlei Martins¹; Maria Assuncao Silva-Dias¹ (mafdsdia@master.iag.usp.br); Meinrat O Andreae² (moa@mpch-mainz.mpg.de); G Frank²; D Chand³; O Schmid³; P Guyon³; J Huth²; S Mathias-Maser²; O Mayol-Bracero²; Magda Claeys³; S Decesari⁴; M C Facchini⁴ (mc.facchini@isao.bo.cnr.it); Sandro Fuzzi⁴; H Graf⁵; Willy Maenhaut⁶; D Rosenfeld⁷; E Swietlicki⁸; Y Rudich⁹; A Gelencser¹⁰; A Hoffer¹⁰

¹University of Sao Paulo, Rua do Matao, Travessa R, 187, Sao Paulo, SP 05508-900, Brazil

²Max Planck Institute for Chemistry, P.O. Box 3060, Mainz D-55020, Germany

³University of Antwerp - UIA, Universiteitsplein 1, Antwerp B-2610, Belgium

⁴ISAC-CNR, Via P. Gobetti 101, Bologna 40129, Italy

⁵Max Planck Institute for Meteorology, Bundesstr. 55, Hamburg D-20146, Germany

⁶University of Gent, Proeftuinstraat 86, Gent B-9000, Belgium

⁷Hebrew University of Jerusalem, Institute of Earth Sciences, Jerusalem 10000, Israel

⁸University of Lund, Division of Nuclear Physics Box 118, Lund S-22100, Sweden

⁹Weizman Institute, Rehovot 76100, Rehovot 76100, Israel

¹⁰Air Chemistry Group, The Hungarian Academy of Sciences, Veszprem 01000, Hungary

The SMOCC campaign aimed at study the links between aerosol-CCN-clouds, with emphasis in the organic aerosol composition, and its effects on cloud microphysics during the dry season in Amazonia. During the dry season, large-scale burning due to deforestation and clearing leads to very large concentration of aerosol particles and CCNs. These smoke aerosols consist mostly of organic matter, include light-absorbing organic and near-elemental carbon species, and are efficient CCN. Concentrations on the order of 600 $\mu\text{g}/\text{m}^3$,