

A42A-06 1145h

Integrating MOPITT and aircraft observations in inverse modeling of Asian CO emissions

Colette L. Heald¹ (heald@fas.harvard.edu); Daniel J. Jacob¹ (djj@io.harvard.edu); Dylan B.A. Jones¹ (dbj@io.harvard.edu); Paul I. Palmer¹ (pip@io.harvard.edu); Jennifer A. Logan¹ (jal@io.harvard.edu); David G. Streets² (dstreets@anl.gov); Glen W. Sachse³ (g.w.sachse@larc.nasa.gov); John C. Gille⁴ (gille@ucar.edu)

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

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

³NASA Langley Research Center, NASA Langley, Hampton, VA 23681

⁴National Center of Atmospheric Research, 1850 Table Mesa Drive, Boulder, CO 80303, United States

Satellite and aircraft observations of trace species provide independent top-down constraints on emissions. We examine the consistency of these very different observations. Daily MOPITT satellite observations and CO data from the TRACE-P aircraft mission over the NW Pacific are applied here to the regional estimation of CO emissions from different Eurasian regions for the spring of 2001. We use the GEOS-CHEM global 3-D model of atmospheric chemistry as the forward model. A priori estimates of Asian emissions are based on gridded inventories for the observation period. We account for the model transport error using an approach based on paired forecasts of CO as well as differences between observations and simulated concentrations. This method accounts for the daily spatial correlations of the errors. We examine the sensitivity of the a posteriori source estimates to the structure of the error covariance as well as the range of Asian emission source strengths defined by the combination of the satellite and aircraft observations. MOPITT observations indicate that emission estimates are underestimated in regions dominated by anthropogenic sources, whereas biomass burning emissions are overestimated. The range of a posteriori solutions provides a better estimate of the uncertainty of the solution than the a posteriori errors and can in some cases exceed the a priori uncertainty on the source. We find that the aircraft and satellite observations are broadly consistent in terms of their constraints on regional CO sources, but that the satellite observations allow for additional source disaggregation.

A43A CC: 220 C-E Thursday 1330h

Aerosol, Ice, and Cloud Properties and Microphysics I Posters (joint with H)

Presiding: S Cho, York University; N T O'Neill, NASA Goddard Space Flight Center

A43A-01 1330h POSTER

Removal of Ultra-Fine Aerosol Particles from the Atmospheric Boundary Layer During Precipitation

Constantin Andronache (1-617-552-6215; andronac@bc.edu)

Boston College Gasson Hall 012, 140 Commonwealth Ave., Chestnut Hill, MA 02467, United States

New aerosol particles are formed in atmospheric environment as a result of the secondary particle production, or homogeneous nucleation of gaseous species. Direct emissions of small particles into atmosphere are related to road traffic, power plants and additional mechanisms involving ion-assisted nucleation. These processes contribute to ultra-fine particle (UFP) presence in atmosphere (defined as particles with diameter less than 100 nm), which can have health effects and can impact cloud properties. UFP formed in the boundary layer (BL) need to grow up to a diameter $d_p \sim 100$ nm to become activated as cloud droplets (CD). The time required to reach $d_p=100$ nm is about 2-3 days for a typical growth rate of 5 nm hr^{-1} , while significant variability was reported from experimental data. If precipitation occurs, most UFP are too small to become CD and some particles are removed by scavenging processes. A model to estimate the UFP wet removal from the BL by rainfall and coagulation is presented.

The scavenging coefficient that describes the decay of aerosol mass in various size bins is a function of aerosol size (d_p), rainfall rate (R), and BL background aerosol. The model is applied to determine the UFP characteristic removal time during precipitation, due to below-cloud scavenging by falling raindrops, coagulation with background aerosol, mixing-in-cloud followed by coagulation with cloud hydrometeors. Results show that during rain events, the 0.5-folding time is $t_{0.5} \sim 1$ hr for $R \sim 1 \text{ mm hr}^{-1}$ for newly created particles ($d_p < 10 \text{ nm}$) and $t_{0.5} \sim 1$ day for larger UFP ($d_p \sim 10\text{-}100 \text{ nm}$). The likelihood of UFP removal at locations with specific precipitation regimes is also illustrated.

A43A-02 1330h POSTER

Zooming in on cirrus with the Canadian Regional Climate Model

Cristina Stefanof¹ (514 3651613; cristina@sca.uqam.ca); Alexandru Stefanof¹ (5149873000; stefanof@sca.uqam.ca); Alain Beaulne³ (5144217246; alain.beaulne@ec.gc.ca); Rodrigo Munoz Alpizar¹ (987 3000; rodrigo@sca.uqam.ca); Wanda Szyrmer² (5143983764; wanda@sca.uqam.ca); Jean-Pierre Blanchet¹ (5149873000 3316; blanchet.jean-pierre@uqam.ca)

¹University of Quebec at Montreal, Department of Earth and Atmospheric Sciences, 201 Av. President Kennedy west, Montreal, QC H3C 3P8, Canada

²University McGill, Department of Atmospheric and Oceanic Sciences, 805 Sherbrooke Street West, Montreal, QC H3A 2K6, Canada

³Canadian Meteorological Centre, 2121 TransCanadae, Dorval, QC H9P 1J3, Canada

The Canadian Regional Climate Model plus a microphysical scheme: two-moments microphysics with three hydrometeor categories (cloud liquid water, pristine ice crystals and larger precipitation crystals) is used to test the simulation in forecast mode using ECMWF data at 0.4×0.4 degree.

We are zooming in on cirrus at higher resolutions (9, 1.8, 0.36 km). We are currently using the data set measured in APEX-E3, measurements of radar, lidar, passive instruments and interpreted microphysics for some flights (G-II, C404, B200). The radar and lidar data are available for high level cirrus. The south west of Japan is the flight region. The dates are March 20, March 27 and April 2, 2003. We first focus on the March 27 frontal system.

We did a rigorous synoptical analysis for the cases. The cirrus at 360 m resolution are simulated. The cloud structure and some similarities between model simulation and observations will be presented.

A43A-03 1330h POSTER

MODIS Terra and Aqua Products and Data Tools Available from the NASA GES DISC

Dimitar Ouzounov¹ (ouzounov@eosdataat.gsfc.nasa.gov); Andrey Savtchenko¹ (asavtche@g0mos16.gsfcmo.ecs.nasa.gov); Dongliang Yuan¹ (dyuan@g0mos16.gsfcmo.ecs.nasa.gov); Gregory Leptoukh¹ (leptoukh@eosdata.gsfc.nasa.gov); Jim Acker¹ (acker@daac.gsfc.nasa.gov); Jim McManus¹ (mcmanus@daac.gsfc.nasa.gov); Darryl Nickless¹ (dnickles@g0mos16.gsfcmo.ecs.nasa.gov); Dana Ostrenga¹ (dostreng@g0mos16.gsfcmo.ecs.nasa.gov); Arun Gopalan¹ (gopalan@eosdata.gsfc.nasa.gov); Suhung Shen¹ (sshenn@daac.gsfc.nasa.gov); Zhong Liu¹ (zliu@daac.gsfc.nasa.gov); Hualan Rui¹ (rui@daac.gsfc.nasa.gov); Bill Teng¹ (teng@eosdata.gsfc.nasa.gov)

¹Goddard Earth Sciences Data and Information Services Center, NASA GSFC, MS 902, Greenbelt, MD 20771, United States

The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC), which includes the GES Distributed Active Archive Center (DAAC), distributes three major groups of MODIS products: Level 1 Radiometric and Geolocation data, and Level 2 and higher levels of Atmosphere and Ocean products. The GES DISC provides a broad spectrum of MODIS support for the Earth Observing System (EOS) Project, covering data access, visualization tools, tools for data search and order, documentation, data content, and science and software support. To optimize data access and usage, the MODIS Support Team (MDST) at the GES DISC has developed a variety of tools. The MODIS Multiple Data Ordering Page (MDOP) provides a convenient way to order several MODIS data sets simultaneously, including Level 1, Level 2, and

Level 3 products. The MODIS Ocean On-demand Spatial Subsetting tool enables the parameter and spatial subsetting of all MODIS Ocean mapped data products from the GES DAAC Search and Order System. The MODIS L3 Atmospheric products Online Visualization and Analysis System (MOVAS) addresses the "HDF-data-order-free" desire of science users for the on-line study of aerosols, water vapor, and clouds on a large regional to global basis, without downloading huge amounts of data. To increase the distribution capacity of the EOS Core System (ECS), the so-called Data Pool has been added, providing a very large (50 TB) anonymous FTP area for users to directly download data of interest, without having to submit orders to the main tape archive. New information about MODIS data products, tools, and services can be found on the Web gateway for MODIS information at <http://daac.gsfc.nasa.gov/MODIS/>

A43A-04 1330h POSTER

Using ATSR Fire Counts to Create Biomass Burning Aerosol Source Inventories: Integration Into the AODSEM Aerosol Optical Depth Analysis Package

Martin Aubé^{1,2} (1-819-564-6350-165; aubema@collegesherbrooke.qc.ca)

Normand T O'Neill² (1-819-821-8000; Norm.Onell@Usherbrooke.ca)

Stéphanie Dumaine Allard¹ (allard_steph@hotmail.com)

David Lavoué³ (David.Lavoue@ec.gc.ca)

Alain Royer² (1-819-821-8000; alain.royer@usherbrooke.ca)

¹GRAPHYCS, Collège de Sherbrooke, 475, rue du Parc, Sherbrooke, QC J1E 4K1, Canada

²CARTEL, Université de Sherbrooke, 2500, boul. de l'Université, Sherbrooke, QC J1K 2R1, Canada

³Meteorological service of Canada, 4905 Dufferin Street, Downsview, ON M3H 5T4, Canada

Tracking of the Aerosol Optical Depth (AOD) is of particular importance in monitoring aerosol contributions to global radiative forcing. Aerosol emissions from forest fires contribute significantly to the atmospheric AOD. The modelling of the AOD spatio-temporal evolution using an aerosol transport model requires accurate and dynamic emission inventories. Current inventories are largely based on monthly or seasonal climatological averages. Since forest fire occurrence is highly variable in time and space, emission inventories of a climatological nature are clearly inadequate as inputs to aerosol transport models. This is especially true near the time and position of large-magnitude forest fires events. In this communication we present a method for improving current inventories of biomass burning aerosol emission. The basic idea is to exploit the dynamic temporal information contained in the ATSR open fire counts database to correct or update monthly databases. Daily temporal variations in emissions rates are obtained by multiplying the climatological inventories with the ratio of ATSR daily fire counts over the monthly daily average of ATSR fire counts. This simple operation results in a daily aerosol emission inventory which maximizes the use made of the knowledge resources imbedded in climatological databases. While the information concerning emission flux and injection height are taken from the climatological inventories the high frequency temporal variations are given by the ATSR dataset. We applied this method to the large Canadian forest fire events of August 1998. The resulting aerosol biomass burning emissions were used as an input to the Aerosol Optical Depth Spatio-temporal Evolution Model (AODSEM V2.0). Results of AODSEM model runs were compared with AOD measurements acquired from the AERONET sunphotometer network and with a control run using original climatological emission inventory data as input. Our results shows the improvements of our new method compared to the more classical one.

URL: <http://www.graphyics.qc.ca/NOMAD/index.html>

A43A-05 1330h POSTER

Analysis of the Transport of Volcanic Ash from the July, 2003 Eruption of the Soufriere Hills Volcano on Montserrat to Puerto Rico

Jason D. White¹ (202-806-9219; jdwhite@howard.edu)

Lizette Roldan¹ (202-806-9219; lroldan@howard.edu)

Vernon Morris¹ (202-806-9088; vmorris@howard.edu)

¹Howard University, 525 College St, NW Room B-21, Washington, DC 20059, United States

The Soufriere Hills Volcano is located on the southern half of the Caribbean island of Montserrat. Montserrat is situated in the northern part of the Lesser Antilles, which is a volcanic island arc formed along the junction of the Atlantic tectonic plate and the Caribbean plate. An eruption of the Soufriere Hills Volcano began in 1995. Periods of small to moderate sized explosions followed. On July 12, 2003, a lava-dome of the volcano collapsed and led to several days of explosions that rocked the island and injected ash into the atmosphere. The aim of the work presented herein is to elucidate the transport mechanism of the volcanic ash from the island of Montserrat to the south-western coast of Puerto Rico and its impact on regional aerosol distributions.

A43A-06 1330h POSTER

The Role of Aerosols in Drizzle Formation

Pamela J Lehr¹ (lehr@mathstat.dal.ca)

Ulrike Lohmann¹ (ulrike@mathstat.dal.ca)

Richard Leitch² (Richard.Leitch@ec.gc.ca)

¹Dalhousie University, Dalhousie University, Halifax, NS B3H 3J5, Canada

²Meteorological Service of Canada, 4905 Dufferin Street, Toronto, ON M3H 5T4, Canada

In October of 2003 seven research flights were carried out over the North Atlantic as a part of the Surface Ocean Lower Atmosphere Study (SOLAS). Each flight followed a similar pattern: a vertical profile through the cloud, sampling above, within and below a stratocumulus cloud layer, as well as 500 feet above the ocean surface. Aerosol size distributions were measured using a TSI-APS (Aerosol Particle Sizer - 0.3-20 micron diameter), a TSI-SMPS (Scanning Mobility Particle Sampler - 10-300 nm), a PMS-PCASP (Passive Cavity Aerosol Spectrometer Probe - 0.15-3 microns) and a PMS-FSSP (Forward Scattering Spectrometer Probe 2-40 microns). Aerosol chemistry was measured using the Aerodyne Aerosol Mass Spectrometer (AMS) and the Particle In Liquid Sampler (PILS). Cloud and precipitation microphysics quantities were measured with a variety of instruments mounted under the wings of the aircraft, including the FSSP that is also used for measuring the size distribution of the cloud droplets. There were also two cloud radars on board. Initial results indicate that the aerosol mass in the boundary layer air feeding the stratocumulus decks was dominated by sulphate and sea salt. Above the boundary layer, the air was found to be extremely clean. Drizzle was present in almost all of the clouds, despite most being relatively thin. The size spectra of aerosols and cloud droplets will be used in conjunction with the precipitation data and aerosol chemistry data to study the role of sea salt aerosols in drizzle formation.

A43B CC: 220 C-E Thursday 1330h

Tropospheric Chemistry and Dynamics Using Data From Measurement of Pollution in the Troposphere (MOPITT) Experiment III Posters

Presiding: J R Drummond, University of Toronto; J C Gille, National Center for Atmospheric Research

A43B-01 1330h POSTER

Global Distributions of Carbon Monoxide Total Column: A Statistical Analysis from MOPITT Data

James Drummond¹

(jim@atmos.physics.utoronto.ca); Jane Liu¹

(jliu@atmos.physics.utoronto.ca); Florian Nichitiu¹

(Nichitiu@atmos.physics.utoronto.ca); Jay Kar¹

(jkar@atmos.physics.utoronto.ca); Holger Bremer^{1,2}

(bremer@iup.physik.uni-bremen.de); Jason Zou¹

(jzou@atmos.physics.utoronto.ca); John Gille³

(gille@ucar.edu)

¹Department of Physics, University of Toronto, 60 St. George Street, Toronto, ON M5S 1A7, Canada

²Institute of Environmental Physics, University of Bremen, PO Box 330440, D-28334, Bremen, Germany

³National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-300, United States

Measurements of Pollution In The Troposphere (MOPITT) on board NASA Terra satellite is a sensor developed for measuring carbon monoxide (CO) from space. The CO measurements made by MOPITT have greatly enhanced our understanding of temporal and spatial distributions of CO in the atmosphere and the mechanisms governing the distributions. In this study, the global CO data are statistically analyzed in terms of CO total column variations with time, latitude, longitude, and altitude. This statistics provides a new and comprehensive overview of global CO distributions in a quantitative way. The information is useful not only to atmospheric science community but also to other disciplines and public, owing to the importance of CO as a major pollutant, a precursor of ozone, and its effects on many atmospheric chemical processes. The CO data have illustrated the combined effects of natural and anthropogenic factors on the CO distributions in the atmosphere. The preliminary results from the analysis are highlighted as follows: (1) The mean CO of the northern hemisphere usually reaches its maximum in April-May, mainly because of low atmospheric oxidation capacity at the time. The maximum CO of the southern hemisphere often appears in October-November due to large fire events. As a result, seasonal variation of global mean CO generally shows two peaks at a level up to 2.0 1018 molecules/cm², in April-May and October-November. (2) As land is a source of CO and the fraction of land increases with latitude, global annual mean CO total column increase with latitude from 1.0 1018 molecules/cm² in the south pole to 2.1 1018 molecules/cm² at 0°, then staying around that level up to the north pole. When looking at CO over land only, a peak of 2.3 1018 between -10°S and 10°N and a trough at 34°N can be found. The former results from the Plateau of Tibet. The CO averaged over oceans increases from the south pole to 50°N and then decreases slightly along latitude. The trend of CO with latitude is similar to that for CO₂. (3) Along longitude circles, global annual mean CO fluctuates from 1.6 to 1.9 1018 molecules/cm², a variation smaller than that across latitudes. The fluctuation is larger over land than that over oceans. (4) Considering both latitude and time, the rate of CO increase with latitude is the smallest in June/July (0.006 1018 molecules/cm² per degree between ±60°) and the largest in April/May (one time bigger than that for June/July). The amplitude of seasonal variation of CO is low in the southern hemisphere at 45°S and 5°S (0.4 1018 molecules/cm² per year). In the northern hemisphere, the amplitude is 0.6 1018 molecules/cm² per year with a small change with latitude. (5) CO total column generally decreases with altitude because of the reduction of air mass. In terms of the global annual mean, CO total column declines at a lapse rate of 0.3 1018 molecules/cm² per kilometer. (6) With a series of daily global mean CO from 2000 to 2004, a short-time trend of 0.025 1018 molecules/cm² per year is found. A long-term trend can be established if MOPITT continues on orbit for a longer period and other space-borne instrument shall be available to replace MOPITT when it is not operating.

A43B-02 1330h POSTER

MOPITT Observation of Large Horizontal Gradients of CO at the Synoptic Scale

Jane Liu¹ (jliu@atmos.physics.utoronto.ca); James

Drummond¹ (jim@atmos.physics.utoronto.ca);

Zouhao Cao² (Z.Cao@ec.gc.ca); Jason Zou¹

(jzou@atmos.physics.utoronto.ca); Holger

Bremer^{1,3} (bremer@iup.physik.uni-bremen.de);

Jay Kar¹ (jkar@atmos.physics.utoronto.ca);

Florian Nichitiu¹

(Nichitiu@atmos.physics.utoronto.ca); John

Gille⁴ (gille@ucar.edu)

¹Department of Physics, University of Toronto, 60 St. George Street, Toronto, ON M5S 1A7, Canada

²Meteorological Service of Canada-Ontario, 867 Lakeshore Road, Burlington, ON L7R 4A6, Canada

³Institute of Environmental Physics, University of Bremen, PO Box 330440, D-28334, Bremen, Germany

⁴National Center for Atmospheric Research, P.O. Box 3000, Boulder, CO 80307-300, United States

Carbon monoxide (CO) generated from incomplete combustion of fossil fuel is one of the major pollutants in the atmosphere. The MOPITT (Measurements Of Pollution In The Troposphere) instrument, on board the Terra satellite is now measuring this atmospheric gas from space for the first time. With the MOPITT CO data, a phenomenon of large horizontal gradients of CO at the synoptic scale was observed. The horizontal concentration of CO varied rapidly by 50-100% in 100 km across a noticeable boundary. This phenomenon lasted one to several days and spanned horizontally 500 -1000 km, appearing at almost all heights of CO retrievals from 850 mb to 250 mb. In comparison with

the corresponding NCEP/NCAR Reanalysis meteorological data, we found that over land this phenomenon often correlates with a shift in the vertical wind direction on the two sides of the boundary. The boundary is mostly aligned with the transition between downward and upward airflows, with ascending air motion correlating with high CO on one side and descending motion with low CO on the other side. The shift in the vertical wind direction is usually associated with synoptic weather processes, such as frontal systems. Over oceans, the phenomenon appears to be related to horizontal wind shear. In addition to case studies, we will also discuss the significance of these new findings in understanding the mechanisms of air pollutant transport and modeling of their spatial distribution patterns.

A43B-03 1330h POSTER

MOPITT Data and Tools Available from the Atmospheric Sciences Data Center

Linda A Hunt¹ (l.a.hunt@larc.nasa.gov)

Nancy A Ritchey¹ (n.a.ritchey@larc.nasa.gov)

¹Atmospheric Sciences Data Center, NASA Langley Research Ctr MS175D 2 S. Wright St., Hampton, VA 23681-2199, United States

The Measurements Of Pollution In The Troposphere (MOPITT) data products are archived and distributed by the Atmospheric Sciences Data Center (ASDC) at NASA's Langley Research Center. Available MOPITT data products include Level 1 radiances and Level 2 derived carbon monoxide. The ASDC also provides access to tools that aid in the visualization and analysis of the MOPITT Level 2 data products. The MOPITT L2 Viewer software package plots images from the MOPITT Level 2 data files. Sample read software extracts data from a MOPITT Level 2 HDF-EOS formatted file and outputs the data in ASCII. The software also allows subsetting by latitude and longitude. Detailed information about the MOPITT data products, tools and documentation are available from the ASDC web site, <http://eosweb.larc.nasa.gov>.

URL: <http://eosweb.larc.nasa.gov>

A43B-04 1330h POSTER

Airborne Measurements of CO by MOPITT-A

Loic Jounot^{1,2} (416-978-5213;

loic@atmos.physics.utoronto.ca); James

Drummond¹ (416-9784327;

james.drummond@utoronto.ca); Denis Dufour¹

(416-946-7543; denis@atmos.physics.utoronto.ca);

Oleg Mikhailov¹ (416-9784327;

oleg@atmos.physics.utoronto.ca); Ron Irvine¹

(416-978-4327; ron@atmos.physics.utoronto.ca);

Jonathan Gero² (617-495-2351;

gero@fas.harvard.edu); Robert Deschambault³

(519-622-2300; robert.deschambault@comdev.ca);

Joe Taylor⁴ (608-263-6750;

joe.taylor@ssc.wisc.edu)

¹University of Toronto, McLennan Labs 60 St George St, Toronto, ON M5S 1A7, Canada

²Harvard University, Department of Earth and Planetary Sciences 20 Oxford St, Cambridge, MA 02138, United States

³COMDEV, 155 Sheldon Drive, Cambridge, ON N1R 7H6, Canada

⁴University of Wisconsin-Madison, Space Science and Engineering Center 1225 W Dayton St, Madison, WI 53706, United States

MOPITT (Measurements of Pollution In The Troposphere) is a carbon monoxide and methane remote sounder launched in 1999 on the Terra spacecraft. An aircraft version of MOPITT (MOPITT-A) has been developed at the University of Toronto to perform validation of MOPITT radiances as well as small scale pollution studies. MOPITT-A is based on the engineering model of MOPITT, modified for flight in NASA's ER-2 research aircraft. In August and September 2000, it participated in the SAFARI 2000 field campaign in South Africa, monitoring CO emissions from biomass burning. This talk will describe the method used to retrieve carbon monoxide concentrations from longwave channel radiances. Special attention will be paid to the September 7th 2000 mission, the highlight of which was the overflight of a large prescribed fire in the vicinity of the Kruger National Park. MOPITT-A is financed by the Canadian Space Agency and the Natural Sciences and Engineering Research Council.

URL: <http://www.atmos.physics.utoronto.ca>