

modeling system. The mesoscale model is used to simulate the development of convection over southern FL during the CRYSTAL-FACE study days and to provide a guide as to how the atmosphere responds to the convection. Data from these model runs is then used to provide initial conditions and mesoscale forcing terms for a LES simulation of detached anvil. Results suggest that the amount of initial condensate present in the anvil simulation has a role in the maintenance and evolution of the cirrus layer comparable to the role played by the mesoscale forcing. Parcel studies and off-line microphysics models are used to describe the interplay between cloud microphysics, mesoscale dynamics, and cloud dynamics.

URL: <http://www.meteo.psu.edu/~rcarver>

A11I MCC: 3010 Monday 1020h

Effects of Biomass Burning Plumes on the Troposphere and Stratosphere II

(joint with B, AE)

Presiding: H Jost, NASA Ames Research Center; D Rosenfeld, Institute of Earth Sciences

A11I-01 1020h INVITED

Boreal Forest Fires - Behavior and Atmospheric Impacts

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Fire is a natural and essential stand-renewing agent in circumboreal forests, and eliminating fire in this region is neither economically possible nor ecologically desirable. In general, boreal fire is managed on the basis of values-at-risk, with high levels of protection afforded to economically and recreationally important areas, while fire is permitted to burn naturally in many remote areas. Current estimates are that an average of 5-15 million hectares burn annually across the boreal zone, with at least 50% of the area burning in largely unmanaged forest. High-intensity crown fires account for the vast majority of the area burned in the boreal zone, particularly in North America. These fires typically consume 20-30 tonnes/ha of fuel, spread at rates up to 100 m/min, and generate intensity levels (or energy release rates) approaching 100,000 kW/m of fire front. Deep forest floor (organic) layers common to boreal forests contribute significantly to high levels of fuel consumption and assist in the propagation of crown fires. When crown fires are sustained through a peak afternoon burning period, they usually produce towering convection columns that can reach the upper troposphere directly. Numerous boreal fire columns reaching 11-14 kilometres in height have been documented in the fire literature. Given the lower altitude of the tropopause at boreal zone latitudes it is not surprising that some boreal fire columns have been recently reported reaching the lower stratosphere. Current global and regional climate models suggest a significant increase in both the severity and frequency of boreal fires under a changing climate, with potentially major impacts on terrestrial carbon storage and the global carbon budget, as well as hemispheric smoke transport. Modelling convection column dynamics is essential to predicting the future transport and atmospheric impacts of boreal fire smoke, and this science requires a solid understanding of fuel consumption and fire behavior on the ground, presenting a solid opportunity for mutually-beneficial collaboration between atmospheric modelers and the wildland fire research community.

A11I-02 1040h

Siberian Biomass Burning Plumes Across the Pacific: Impact on Surface Air Quality in the Pacific Northwest

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During the summer of 2003, we conducted ground and airborne observations of CO, O₃ and aerosols in the Pacific Northwest. The airborne data is discussed by Bertschi and Jaffe. In this paper we discuss the surface data. Observations were made at the Cheeka Peak Observatory on the remote northwest tip of Washington state and we have supplemented this with data from the regional Puget Sound air quality network. In two cases we observed significant enhancements in surface CO, O₃ and aerosols associated with the large Siberian biomass fires which occurred during the summer of 2003. The first episode occurred on June 2-3, 2003. During this period our aircraft observations and the NAAPS global model identified significant enhancements due to long range transport of emissions from Siberian fires and this was also seen at surface sites around the Puget Sound. In some locations the ozone enhancements were significant and may have contributed to a local air pollution episode two days later. In the second case, on August 4-5, our aircraft observations and the NAAPS global model again confirmed the presence of Siberian biomass burning emissions. This was seen at our Cheeka Peak site as a substantial elevation in CO and aerosols, but with a more modest enhancement in O₃. During this period, aerosol concentrations were elevated to 10-15 ug/m³ (PM 2.5) around the Puget Sound. Our observations demonstrate that long range transport can occur during summer and that it can have a significant influence on surface air quality in the western U.S.

A11I-03 1055h INVITED

Effects of Smoke Aerosols on Atmospheric Composition and Cloud Properties Over Amazonia: Results From the LBA-SMOCC-2002 Campaign

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We investigated the emission of smoke from biomass burning, its regional distribution, and its effects on cloud microphysics during the LBA-SMOCC experiment in Amazonia, September-October 2002. The campaign consisted of airborne, ground-based, remote-sensing, and modeling components. Two instrumented aircraft investigated trace gases, aerosol properties and cloud microphysics across a large region that comprised highly polluted and essentially pristine air masses. At a ground site, we made continuous measurements of trace gases and a large suite of aerosol properties, and collected samples for laboratory analysis. Measurements spanned from the peak of the burning season, with high smoke concentrations, to fairly clean conditions in the early rainy season. We found high loadings of smoke particles and pyrogenic trace gases in the boundary layer over vast reaches of Amazonia, and evidence for efficient vertical transport of smoke into the free troposphere. Smoke aerosols had pronounced effects on the radiation budget, cloud microphysics and precipitation formation over Amazonia, as shown by in-situ measurements and remote sensing data. The campaign was accompanied by an intensive modeling effort, which proved very effective in understanding and predicting the conditions encountered by the field team.

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A11I-04 1115h

Multi-platform observations of Siberian forest fires

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Observations of aerosol in the lower stratosphere during northern summer indicate that aerosol is transported from the lower troposphere into the stratosphere due to intense boreal fires. Observations of Siberian fires in the Spring of 2003 are discussed to illustrate how multi-platform data can be used to study these events. MODIS aerosol optical depths, MOPITT CO mixing ratios, and POAM aerosol extinction data are used in an analysis of the Spring 2003 fires. Aerosol and CO is injected into the troposphere, and enhanced POAM aerosol appears in the lower stratosphere, in May. A historical perspective is given based upon POAM, SAGE, and TOMS data for years between 1985 and 2000, excluding 1991-1995 (the period of time in which Pinatubo aerosol was influential). TOMS aerosol optical depths at latitudes between 50 and 70 N are large (due to boreal fires) during the same years in which enhanced aerosol extinction is also observed several km above the thermal tropopause. The longitudinal distribution of the aerosol enhancements in the lower stratosphere shows a preference for longitudes over eastern Siberia.

A11I-05 1130h INVITED

Modeling the transport of emissions from boreal forest fires - a review

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During the last few years, evidence has accumulated that boreal forest fires emitting huge amounts of aerosols and trace gases can have a great impact on the concentrations of these species far away from the location of the burning, both in the troposphere and stratosphere. In the first part of this talk, a brief overview of the highlights of model-supported case studies of the

long-range transport of boreal forest fire emissions will be given. For instance, it is now known that Canadian forest fire emissions can impact photochemical ozone formation in the southeastern United States, aerosols, CO and ozone from Canadian boreal fires can be transported all the way to Europe, transport of emissions into the stratosphere occurs, spectacular global transport events resulted from fires in Siberia in 2003, and strong burning seasons can strongly affect the chemical composition of the entire northern hemisphere troposphere. In the second part of the talk, factors will be reviewed that are critical for a successful simulation of the transport of boreal forest fire emissions and that limit the accuracy of transport models. These factors include the availability of suitable data to locate fires, estimate emission strengths and effective emission injection height, and the critical issue of convection above the fires. Convection can sometimes be enhanced or triggered over the fires due to the extra buoyancy created by the fires themselves as well as radiative processes. While very few dynamic models are available to simulate these processes on the local scale, global models normally do not include them at all, and in fact still have problems simulating small-scale (but possibly very deep) convection even if not triggered by fire. Improvements are needed in this respect, especially for quantifying the transport of emissions to the stratosphere.

A11I-06 1150h

Modeling and Mechanisms of Intercontinental Transport of Biomass-Burning Plumes

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With the aid of fire products from GOES and MODIS, the NRL Aerosol Analysis and Prediction System (NAAPS) successfully monitors and predicts the formation and transport of massive smoke plumes between the continents in near real time. The goal of this system, formed under the joint Navy, NASA, and NOAA sponsored Fire Locating and Modeling of Burning Emissions (FLAMBE) project, is to provide 5 day forecasts of large biomass burning plumes and evaluate impacts on air quality, visibility, and regional radiative balance. In this paper we discuss and compare the mechanisms of intercontinental transport from the three most important sources in the world prone to long range advection: Africa, South/Central America, and Siberia. We demonstrate how these regions impact neighboring continents. As the meteorology of these three regions are distinct, differences in transport phenomenon subsequently result, particularly with respect to vertical distribution. Specific examples will be given on prediction and the impact of Siberian and Central American smoke plumes on the United States as well as transport phenomena from Africa to Australia. We present rules of thumb for radiation and air quality impacts. We also model clear sky bias (both positive and negative) with respect to MODIS data, and show the frequency to which frontal advection of smoke plumes masks remote sensing retrievals of smoke optical depth. URL: <http://www.nrlmry.navy.mil/flambe/>

A11I-07 1205h

Using MOPITT data and a Chemistry and Transport Model to Investigate Injection Height of Plumes from Boreal Forest Fires

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Trace gas emissions from boreal forest fires are a significant factor in atmospheric composition and its interannual variability. A number of recent observations of emissions plumes above individual fire events (Fromm and Servranckx, 2003; COBRA 2003; Lamarque et al., 2003; Wotawa and Trainer, 2000) suggest that vertical properties of forest fire emission plumes can be very different from fossil fuel emission plumes. Understanding and constraining the vertical properties of forest fire emission plumes and their injection into the atmosphere during fire events is critical for accurate modeling of atmospheric transport and chemistry. While excellent data have been collected in a handful of experiments on individual fire events, a systematic examination of the range of behavior observed in fire events has been hampered by the scarcity of vertical profiles of atmospheric composition. In this study, we used a high-resolution model of boreal forest fire emissions (Kasichke et al. in review) as input to the Goddard/UM CTM driven by the GEOS-3 DAS, operating at 2 by 2.5 degrees with 35 vertical levels. We modeled atmospheric injection and transport of CO emissions during the fire season of 2000 (May-September). We altered the parameters of the model to simulate a range of scenarios of plume injection, and compared the resulting output to the CO profiles from the MOPITT instrument. The results presented here pertain to the boreal forest, but our methods should be useful for atmospheric modelers hoping to more realistically model transport of emission plumes from biomass burning. References: COBRA2003: see http://www.fas.harvard.edu/coBRA/smoke_canada_030530.pdf Fromm, M. and R. Servranckx, 2003. "Stratospheric Injection of Forest Fire Emissions on August 4, 1998: A Satellite Image Analysis of the Causal Supercell Convection." Geophysical Research Abstracts 5:13118. Kasichke, E.S.; E.J. Hyer, N.H.F. French, A.I. Sukhminin, J.H. Hewson, B.J. Stocks, in review. "Carbon Emissions from Boreal Forest Fires - 1996 to 2002." Lamarque, J.-F., D.P. Edwards, L.K. Emmons, J.C. Gille, O. Wilhelmli, C. Gerbig, D. Prevedel, M.N. Deeter, J.X. Warner, D.C. Ziskin, B. Khattatov, G.L. Francis, V. Yudin, S. Ho, D. Mao, J. Chen, J.R. Drummond. "Identification of CO plumes from MOPITT data: Application to the August 2000 Idaho-Montana forest fires." Geophysical Research Letters 30(13):1688, doi:10.1029/2003GL017503. Wotawa, G. and M. Trainer. "The influence of Canadian Forest Fires on Pollutant Concentrations in the United States." Science 288:324-328.

A12A MCC: Level 1 Monday 1330h

Comparative Photochemical Modeling of Earth and Planetary Atmospheres Posters (joint with P, SA)

Presiding: Y L Yung, California Institute of Technology; G R Gladstone, Southwest Research Institute

A12A-0064 1330h INVITED POSTER

Terrestrial Photochemistry: an aid for planetary evolution and astrobiology

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In the last 20-30 years knowledge of terrestrial photochemistry has improved enormously with advances in measurement technology affecting both laboratory and field measurements. And advances in computer hardware and software have also led to important contributions. Interestingly photochemistry studies have also influenced terrestrial studies in certain chemical families before it became of interest for the Earth. On the Earth interesting photochemistry spans the pressure regime from 1 atmosphere to the exosphere, so somewhat less than on Jupiter and Venus in terms of pressure. Temperature ranges from 100 K to 1500 K, not as cold as tropospheric regions of the outer planets but as warm as Jupiter's exosphere (but much less "warm" than the outer regions of the extra-solar Jupiters where temperatures likely reach 10-20,000K. In this talk I will present a perspective on recent terrestrial photochemical modelling visiting urban air quality and tropospheric ozone, PSC impacts on stratospheric ozone and aerosols and mesospheric chemistry and attempt to relate to planetary evolution and astrobiology.

A12A-0065 1330h INVITED POSTER

Photochemistry of the Atmospheres of Mars and Venus

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Mars photochemistry is mainly the CO₂-H₂O chemistry, which was studied by McElroy and Donahue (1972) and Parkinson and Hunt (1972) thirty years ago. However, there is an increasing disagreement between the recent experimental data and the latest models of Mars photochemistry: (1) the standard gas-phase chemistry predicts too low CO and O₃, (2) all modifications in gas-phase chemistry suggested ten years ago to fit CO and O₃ have not been confirmed, (3) recent data on CO are even higher than that in the modified models, (4) the observed H₂ is far below the model values, (5) the MGS/TES mean H₂O exceeds that in the models, (6) the measured upper limit to H₂O₂ is much smaller than the model predictions, and (7) the low latitudinal variations of the O₂ dayglow at 1.27 μm and O₂ at late northern spring and summer disagree with the very strong variations of H₂O and question the basic concept of Mars photochemistry. However, the inclusion of even one heterogeneous reaction (sink of peroxide on ice and ice-covered dust) removes most of these disagreements. Heterogeneous chemistry should exist on Mars, and Mars photochemical models are inadequate without heterogeneous chemistry. A significant progress in Mars photochemistry and dynamics is expected from photochemical GCMs. These models do not account for small-scale mixing and long living species (H₂, O₂, and CO) and need too much computational time to try various version. Therefore, a combination of a photochemical GCM with a 1D global-mean model may be the best tool to study Mars photochemistry and dynamics. Venus photochemistry is a challenging problem, which was studied mostly in early 1980's after the success of the Pioneer Venus and Venera missions. Later, the important data on the composition of the lower (subcloud) atmosphere were obtained from ground-based spectroscopy of Venus night-side and analyzed using a chemical model. Venus photochemistry involves three basic tasks: the atmospheric composition above and below 60 km and the formation and structure of the cloud layer. H₂O is strongly depleted by sulfuric acid above the clouds, and photolysis of HCl is the main source of odd chlorine Cl[•] and odd hydrogen H[•]. H[•] is much less abundant than Cl[•] because of the reaction OH + HCl → H₂O + Cl. SO₂ is a source of sulfur chemistry, which results in the formation of the H₂SO₄ clouds and is important in the balance of CO, O, and O₂. NO may be formed by lightning and significantly affect Venus chemistry. The major difficulty for the models above 60 km is to fit the upper limit O₂ ≤ 0.3 ppm. The lower atmosphere is hot and dense, and slow reactions with high activation energy may proceed there. However, the simple assumption of thermochemical equilibrium is typically misleading. Analysis of the CO₂-CO-SO₂-H₂SO₄-OCS system agrees with the observational data on the OCS and CO vertical profiles. The clouds consist of H₂SO₄ and probably S_n and FeCl₃. Venus photochemistry is complex, some observational data are insufficient and missing, and a new spacecraft mission with the advanced instruments for analysis of the chemical composition of the atmosphere and clouds is highly desirable.

A12A-0066 1330h INVITED POSTER

Photochemistry of the Giant Planets

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Photochemistry in the hydrogen-dominated atmospheres of Jupiter, Saturn, Uranus, and Neptune is interesting and complex despite the large heliocentric distances involved. Methane photochemistry dominates in the stratospheres of the giant planets; other "parent" molecules like H₂O, NH₃, and H₂S are trapped in condensed phases and are confined to the troposphere. Methane photolysis initiates the production of complex hydrocarbons like C₂H₆, C₂H₂, C₂H₄, CH₃C₂H, C₄H₂, C₆H₆, and CH₃ - all of which have been detected on Jupiter and Saturn, and some of which have been detected on Uranus and Neptune. The photochemistry of ammonia and phosphine are coupled in the tropospheres of Jupiter and Saturn. Predicted products of this interaction include N₂, N₂H₄, P₄, P₂H₄, NH₂PH₂, with much lesser amounts of HCP, HCN, and other nitriles like HC₃N, CH₃CN, and C₂H₃CN, and complex organonitrogen compounds like acetaldehyde. None of these species have been definitively detected on the giant planets (except for HCN on Neptune and Jupiter). Water resides too deep in the tropospheres of the giant planets to interact with ultraviolet photons; however, oxygen is introduced to the upper atmospheres of the