ozone and those caused by aerosols and clouds. Systematic differences in cloud cover are shown to be the most important factor in determining regional differences in UV radiation reaching the ground for locations at the same latitude (e.g., the summertime differences between Australia and the US southwest). Regional and seasonal ozone differences are most important at higher latitudes in both hemispheres for causing high values of UVB irradiances.

A11G-05 1130h INVITED

TOMS and Volcanic SO_2: an Important aid to the Understanding of Volcanism and the Atmosphere

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It is impossible to measure gas fluxes from the ground in a major volcanic event, but the TOMS instrument provided the first quantitative measurements of individual stratospheric eruptions, because SO_2 could be measured as well as O_3. The measurements were quickly noticed by scientists, because the masses of sulfur erupted often far exceeded what they expected to find, based on petrology and its supposed constraints, by surprising factors of 10 to 100. This result is still not well understood, and is an important driving idea for volcanologic research. TOMS was applied globally and the explosive volcanic flux of SO_2 to the atmosphere was compiled for the first time using direct measurements –an important input to earth systems analysis. Comparison of TOMS volcanic cloud SO_2 maps with infrared volcanic ash cloud maps showed that there is often spatial separation of gas-rich volcanic clouds emplaced higher in the atmosphere and ash-rich clouds which are lower and which drift in different directions because of windshears. Sequential examination of TOMS data showed that SO_2 masses in volcanic clouds increases for 24 hours or more after eruption. The best explanation of this increase is that ice which forms early in volcanic clouds captures SO_2 which is then released again as the stratospheric ice sublimes. The presentation will document all of the best examples of the discoveries listed above. Volcanologists and those interested in the mitigation of volcanic cloud hazards have repeatedly suggested that geostationary SO_2 and ash sensing capability at higher spatial resolution would provide important new science opportunities. The sensors of the next remote sensing era (MODIS, ASTER, SEVIRI, OMI, ABI) bring us closer to achieving these goals.

URL: http://skye.gsfc.nasa.gov/index.html

A11G-06 1150h

Assessing the Ecological Impact of the Antarctic Ozone Hole Using Multisensor Satellite Data

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We have developed a satellite-based numerical simulation for determining the extent to which enhanced solar ultraviolet radiation (UVR) under the springtime Antarctic ozone decrease affects primary production throughout the Southern Ocean. This satellite approach using NASA Sea-viewing Wide Field-of-view Sensor (SeaWiFS) data for chlorophyll and phytoplankton biomass, passive microwave data for sea ice concentration, and Total Ozone Mapping Spectrometer (TOMS) data for total column ozone and cloud reflectivity, circumvents many of the limitations involved with extrapolating point field measurements to larger geographical areas. The satellite data are used to force a physiology-based model of phytoplankton growth in response to UV-B, UV-A, and photosynthetically active radiation (PAR). Comparison with field measurements in the Western Antarctic Peninsula region shows excellent agreement. UVR-induced losses of surface phytoplankton production are substantial, although depth-integrated phytoplankton losses are considerably smaller.

A11G-07 1205h

Evaluation of a Multi-Decadal Siimulation of Stratospheric Ozone by Comparison with Total Ozone Mapping Spectrometer (TOMS) Observations

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One key application of atmospheric chemistry and transport models is prediction of the response of ozone and other constituents to various natural and anthropogenic perturbations. These include changes in composition, such as the previous rise and recent decline in emission of man-made chlorofluorcarbons, changes in aerosol loading due to volcanic eruptions, and changes in solar forcing. Comparisons of hindcast model results for the past few decades with observations are a key element of model evaluation and provide a sense of the reliability of model predictions. The 25-year data set from Total Ozone Mapping Spectrometers is a cornerstone of such model evaluation. Here we report evaluation of a three-dimensional multi-decadal simulation of stratospheric composition. Meteorological fields for this off-line calculation are taken from a 50-year simulation of a general circulation model. Model fields are compared with observations from TOMS and also with observations from the Stratospheric Aerosol and Gas Experiment (SAGE), Microwave Limb Sounder (MLS), Cryogenic Limb Array Etalon Spectrometer (CLAES), and the Halogen Occultation Experiment (HALOE). This overall evaluation will emphasize the spatial, seasonal, and interannual variability of the simulation compared with observed atmospheric variability.

A11H MCC: 3016 Monday 1020h

Tropical Cirrus Anvils: Properties and Processes II *(joint with SA, AE)*

Presiding: **E Jensen,** NASA Ames Research Center**; D E Anderson,** NASA Headquarters

A11H-01 1020h

The role of cubic ice in dehydration of cold clouds

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Cubic ice is a metastable form of ice with very similar physical properties but different crystal symmetry than normal, hexagonal ice. Below 200 K, water preferentially nucleates to Ic, then transforms to the more stable Ih in minutes to days. As a metastable phase, cubic ice will necessarily have a higher vapor pressure than hexagonal ice. A cloud parcel model shows that nucleation to cubic ice, conversion to hexagonal ice, and the vapor pressure differential together produce larger ice crystals that can more effectively dehydrate air. The modeled effect is largest at 180 to 200 K, just the range most important for the tropical tropopause and polar stratospheric clouds. The cloud model also produces a wider size distribution when cubic ice is included, in agreement with observations. Past observations of cubic ice in the atmosphere are consistent with the modeled behavior.

A11H-02 1035h

Intercomparison of in situ ice water measurements on the WB-57 with radar measurements from the ER-2 during CRYSTAL-FACE

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One of the major goals of the 2002 CRYSTAL-FACE mission was to intercompare and validate measurements of microphysical quantities – ice crystal size distributions, ice mass, and water vapor - by a variety of remote and *in-situ* instruments. However, a direct comparison of remote and *in-situ* measurements is difficult because they involve very different fields of view. CRYSTAL-FACE provided an opportunity for assessing how well such intercomparisons can be made and for determining the type of flight plans that will be necessary for validation of future satellite instruments. During CRYSTAL-FACE, remote and in-situ instruments were placed on different aircraft (NASA's ER-2 and WB-57), and the two planes flew in tandem so that the *in-situ* payload flew along the field of view of the remote instruments. We show here, however, that even with this type of careful flight planning, it is not always possible to guarantee with certainty that remote and *in-situ* instruments are viewing the same air parcel. We use ice water data from the *in-situ* Harvard Total Water and Water Vapor instruments, and the remote Goddard Cloud Radar System (CRS), for the flight of July 16, 2002. This date provided the best opportunity for comparison because the planes made multiple passes through cirrus thick enough to be detected by CRS. We show that agreement between Harvard ice water and CRS is a strong function of the horizontal separation and the time delay between the aircraft transects. This type of analysis should guide flight planning for future intercomparison efforts, whether for aircraft-borne or satellite instrumentation.

A11H-03 1050h

Evidence That Most Florida Anvil Crystals Derive From Midtropospheric Aerosols

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NASA's 2002 CRYSTAL-FACE field experiment focused on the formation and properties of cirrus cloud systems in southern Florida, including extensive measurements of aerosol number and size distribution throughout the atmospheric column. Coupling these field measurements with large-eddy simulations that resolve the size distributions of aerosols and cloud particles, we find several lines of evidence pointing to the predominance of midtropospheric aerosols as the seminal cloud nuclei for anvil crystals, in contrast to the general assumption that boundary layer aerosols are more important. Turning first to measurements made during the only penetration of a powerful updraft during the campaign, at an altitude of approximately 10 km on July 18, we find that the inclusion of tropospheric aerosols above 6 km is required to properly simulate the large number of cloud particles measured in the updraft. Furthermore, in both model simulations and observations, peak particle numbers are found not in the heart of the updraft core at 10 km, where peak supersaturations are located, but instead are found in the upwind entraining boundary of the updraft. Observed and modeled particle size distributions also demonstrate that the additional particles in the entraining region are much smaller than those in the heart of the core, consistent with cloud particle activation on recently-entrained tropospheric aerosols. Turning next to upper anvil ice crystal size distributions, observations consistently indicate peak crystal numbers in the 20 to 30 um diameter range. Model simulations reproduce this peak accurately when aerosols are included throughout the atmospheric column,but the peak shifts to 40 to 50 um when excluding aerosols above 6 km,and further shifts to 90 um when excluding aerosols above 2 km, which well exceeds the boundary layer depth. While no anvil data are available on July 18, coincident with the strong updraft measurements, we find that upper tropospheric aerosols are equally important to simulated anvil crystal numbers and size distributions on other days when cumulonimbus systems and aerosols were simultaneously measured, including July 11, 16, 19, 21, 28, and 29.

A11H-04 1105h

Evidence That Ambient Nitric Acid Increases Relative Humidity in Low-Temperature Cirrus Clouds

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In situ measurements of the relative humidity with respect to ice (RH_i) and nitric acid (HNO_3) were made in both natural and contrail cirrus clouds in the upper troposphere. At temperatures lower than 202K, RH_i values show a sharp increase to average values over 130% in both cloud types. These enhanced RH_i values are attributed to the presence of a new class of HNO3-containing ice particles. We propose that these particles have HNO_3-trihydrate-like clusters or partial layers which interfere with the ice-vapor steady state. These RH_i observations alter expected cloud properties in the upper troposphere and the effectiveness of the dehydration process. The potential role for HNO_3 represents a new link between natural and anthropogenic nitrogen oxide emissions and climate change.

A11H-05 1120h

Tropical cirrus lifecycle and relation to the upper tropospheric water vapor

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Tropical cirrus lifecycle, evolution and relation to the upper tropospheric water vapor (UTWV) are examined by analyzing satellite derived cloud data, UTWV data, and NCEP/NCAR reanalysis wind field. Building upon the existing ISCCP data and the TOVS product, a global (except polar region), six-hourly cirrus dataset are developed from two infrared radiance measurements roughly at 11 and 12 micron. The analysis in this study is conducted in a Lagrangian framework, which assumes that cirrus, like other tracers, drift with the upper tropospheric wind, while at the same time, going through their lifecycle from formation to maturation to decay. The Lagrangian trajectory analysis shows that the decay of deep convection is immediately followed by the growth of cirrostratus and then the decay of cirrostratus is followed by the growth of cirrus. Cirrus properties continuously evolve along the trajectories as they gradually thin out and move to the lower levels. Typical tropical cirrus systems last for 19 - 30 hours, with a standard deviation of about 16 hours. This is much longer than cirrus particle lifetimes (0.8 - 8 hours), suggesting that there are other processes (e.g. large-scale lifting) that oppose particle sedimentation to maintain tropical cirrus. Consequently, tropical cirrus can advect over large distances, about 600 - 1000 km, during their lifetimes. For almost all current GCMs, this distance spans more than one grid box requiring that the water vapor and cloud water budgets include an advection term. Based on their relationship to convective systems, detrainment cirrus are distinguished from in situ cirrus. It is found in this study that more than half of the tropical cirrus are formed in situ. The interaction between cirrus and UTWV is explored by comparing the evolution of the UTWV along composite clear trajectories and trajectories with cirrus. Cirrus are found to be associated with a moister upper troposphere and a slower decrease rate of UTWV. Moreover, elevated UTWV level has a longer duration than cirrus. The amount of water in cirrus is too small for evaporation of cirrus ice particles to moisten the upper troposphere. Rather, it is large-scale and small-scale transport that brings water vapor upward to maintain the high UTWV level. Finally, the maintenance of UTWV is discussed by using a simple, conceptual model.

A11H-06 1135h

Drying and moistening by deep sub-tropical and tropical convection in large-eddy simulations of CRYSTAL-FACE and CEPEX field measurements

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Deep convection has been proposed to be a leading mechanism controlling the moisture in the lower stratosphere. We evaluate this hypothesis with large-eddy simulations that resolve the size distributions of aerosols and cloud particles over 100-km square square domain using pre-convective Miami and PARSL soundings, initiating convection with enough of a surface heat source to match the observed anvil altitudes. Differencing the moisture field after the anvils decay with the initial state, we find that convection predominantly moistens the transitional tropopause layer (TTL), although some drying is predicted in localized layers. Beyond the sub-tropical convection of Florida we also use frostpoint hygrometer soundings obtained during the CEPEX mission in the tropical western Pacific, which show repeated evidence of supersaturated layers within the TTL. In such cases we find that deep convection dries out the supersaturated layers while moistening the air above and below. We also analyze the environmental and temporal dependence of the time constants of sedimentation, evaporation, and mixing of water.

A11H-07 1150h

Impacts of Nucleating Aerosol on the Characteristics of Cumulus Convection and the Associated Anvils During CRYSTAL-FACE

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Unusually high aerosol concentrations were observed on 28 July 2002, during the CRYSTAL-FACE field program conducted over the Florida peninsula. The impacts of nucleating aerosol on the characteristics of the cumulus convection and associated anvils that developed on this day have been investigated using the Regional Atmospheric Modeling System (RAMS). Simulations were conducted in which the concentrations of cloud condensation nuclei (CCN), giant CCN (GCCN) and ice forming nuclei (IFN) were varied from "clean" air concentrations to "dirty" air concentrations. The location and strength of the cumulus convection, the depth and longevity of the anvil, hydrometeor size distributions, and the amount and distribution of precipitation at the surface were all affected by these variations in nucleating aerosol concentrations.

A11H-08 1205h

Simulations of the July 16 and 21 CRYSTAL-FACE Cirrus Cases Using a Cloud-Resolving Model Forced by a Mesoscale Model

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To understand what could influence the evolution and maintenance of tropical anvil cirrus, we present results from a paired mesoscale-cloud scale numerical

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 fires 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 airmasses. 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 show 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