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The Polar Ozone and Aerosol Measurement (POAM) III instrument measures atmospheric optical depth in nine spectral bands (from 354 to 1018 nm) using the solar occultation technique. From these fundamental measurements it is possible to retrieve altitude profiles of O3, NO2, H2O, and O2 (or total) density, as well as aerosol extinction, in the stratosphere and upper troposphere. POAM III was launched on the SPOT 4 satellite in March of 1998 and is still in routine operation, making measurements at high latitudes in both hemispheres. In this paper we summarize the algorithms used to produce the POAM III version 3 dataset. The first step of the retrieval process involves the derivation of absolute pointing information and normalization of the measured radiances to produce atmospheric transmission profiles. Conversion of the resulting transmission data to geophysical profiles is achieved via a two-step process, beginning with a spectral inversion to partition the various gas and aerosol components of the measured slant optical depth, followed by a spatial inversion to produce altitude profiles of gas density and aerosol extinction from the path integrated quantities. Both steps of the retrieval process utilize the technique of optimal estimation for the numerical inversion. A formal error analysis of the version 3 retrievals is also presented, including estimates of the total random error budget for the retrieved profiles. Results of this analysis compare well with independent estimates of retrieval precision obtained by calculating the retrieval variances in geophysically quiescent time periods.

URL: http://www.cpi.com

A42A-0105 1330h POSTER

The Odin Atmospheric Mission

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The Odin satellite was launched on 20 Feb 2001 and has begun its joint Astrophysics and Aeronomy mission. Odin is a joint project between Sweden, Finland, France and Canada with various parts of the satellite and its instruments being built in the various countries. The aeronomy mission is aimed at understanding the physical and chemical processed that control the distribution and temporal behaviour of various trace gases in the stratosphere and mesosphere, in particular ozone and water vapour as well as gases controlling the destruction of ozone. To this end Odin carries two instruments: a sub-mm radiometer SMR and an Optical Spectrograph and Infra Red Imaging system both particularly suited to the measurement of different gases. The sub-mm region is perhaps the best region to measure ClO that is closely related to catalytic ozone destruction during the polar winters while the optical spectrograph will allow us to retrieve NO2 as well a BrO with good precision. Both of these gases are also intimately related to the control of ozone concentrations in the stratosphere. Further because of the close cooperation with the astronomical community the SMR measure the strongest sub-mm line of water vapour making Odin especially suited for measurements in the upper mesosphere where it will be able to make single profile measurements to altitudes above 80 km.

Odin is a Swedish-led satellite project funded jointly by Sweden (SNSB), Canada (CSA), Finland (Tekes) and France (CNES).

A42B MC: 123 Thursday 1330h

SAFARI 2000: The Southern African Regional Science Initiative II

Presiding: **H Annegarn,** University of the Witwatersrand**; M King,** NASA Goddard Space Flight Center

A42B-01 1330h

Overview and Stratification of the Meteorological Conditions During the SAFARI 2000 Dry Season Campaign

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As part of the Southern African Regional Science Initiative, SAFARI 2000, an overview of the meteorology of southern Africa during the dry season intensive field campaign is presented. Atmospheric conditions during the SAFARI 2000 dry season campaign of August-September 2000 are examined, classified, and stratified according to general synoptic types and horizontal and vertical transport characteristics. In addition to the chronological examination of the evolution of the synoptic conditions responsible for the observe, severe southern African aerosol events, similar days are grouped together and mean characteristics of the vertical structure, horizontal and vertical transports, synoptic circulations and the frequency of occurrence are presented. Of particular interest is the evolution of the chemically and optically impacted southern African atmosphere during the last week of August and the first 10 days of September, 2000. Ground-based, in-situ and remotely sensed data sets are utilized to characterize this period. The synoptic conditions during the intensive field campaign are placed into a larger regional and global climatological context so as to allow for the extrapolation of the findings of SAFARI 2000 intensive campaigns to time periods outside of the intensive episodes of direct observation. The results of direct comparisons of the synoptic conditions experienced during SAFARI 2000 to those conditions experienced during the Southern African Fire-Atmosphere Research Initiative, SAFARI-92, will also be presented.

A42B-02 1345h INVITED

Cloud and Radiation Studies during SAFARI 2000

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Though the emphasis of the Southern Africa Regional Science Initiative 2000 (SAFARI-2000) dry season campaign was largely on emission sources and transport, the assemblage of aircraft (including the high altitude NASA ER-2 remote sensing platform and the University of Washington CV-580, UK MRF C-130, and South African Weather Bureau JRA in situ aircrafts) provided a unique opportunity for cloud studies. Therefore, as part of the SAFARI initiative, investigations were undertaken to assess regional aerosol-cloud interactions and cloud remote sensing algorithms. In particular, the latter part of the experiment concentrated on marine boundary layer stratocumulus clouds off the southwest coast of Africa. Associated with cold water upwelling along the Benguela current, the Namibian stratocumulus regime has received limited attention but appears to be unique for several reasons. During the dry season, outflow of continental fires and industrial pollution over this area can be extreme. From below, upwelling provides a rich nutrient source for phytoplankton (a source of atmospheric sulfur through DMS production as well as from decay processes). The impact of these natural and anthropogenic sources on the microphysical and optical properties of the stratocumulus is unknown. Continental and Indian Ocean cloud systems of opportunity were also studied during the campaign.

Aircraft flights were coordinated with NASA Terra Satellite overpasses for synergy with the Moderate Resolution Imaging Spectroradiometer (MODIS) and other Terra instruments. An operational MODIS algorithm for the retrieval of cloud optical and physical properties (including optical thickness, effective particle radius, and water path) has been developed. Pixel-level MODIS retrievals (1 km spatial resolution at nadir) and gridded statistics of clouds in the SAFARI region will be presented. In addition, the MODIS Airborne Simulator flown on the ER-2 provided high spatial resolution retrievals (50 m at nadir). These retrievals will be discussed and compared with in situ observations.

A42B-03 1400h INVITED

Physical and Chemical Characterization of Southern African Aerosols and Trace Gases

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In support of the Southern African Fire-Atmosphere Research Initiative (SAFARI-2000), the University of Washington carried out thirty-one research flights over five countries in Southern Africa. These flights provided in situ measurements of the physical and chemical properties of the aerosol and clouds in the region, as well as remote sensing measurements of optical depths, up and down irradiances, and surface reflectivities. Vertical profiles of various gases and aerosols in the region will be shown. During the period of the measurements (August-September 2000), biomass burning was an important source of atmospheric aerosols and gases. Emission ratios, emission factors, and the characteristics of trace species produced by biomass burning will be shown. This paper will also serve as an introduction to several other papers in this session.

URL: http://cargsun2.atmos.washington.edu/sys/research/safari/

A42B-04 1415h

"River of Smoke" - Characteristics of the Southern African Springtime Regional Biomass Burning Haze

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The atmosphere over southern Africa during the austral spring (August to October) is characterised by episodes of intense haze, lasting several days at a time. Results from the SAFARI 92 field campaign developed

an understanding of regional-scale atmospheric transport over the region in the nature of an anti-cyclonic gyre, and the importance of biomass burning of the African savanna as an important source of atmospheric trace gases and aerosols. However the highest concentrations of biomass fires occurs to the north of 15 degree S latitude, in the zone of tropical easterly winds, while the anticyclonic gyre, and much lower fire emission intensity, occurred to the south of this latitude. Measurements during the SAFARI 2000 Regional Science Initiative dry season intensive field campaign (August and September 2000) have revealed a coupling of these two synoptic systems for several days at a time during the austral spring, allowing the dense biomass burning plumes to be fed into the southerly system over southern Angola and northern Namibia, and to be transported towards the south-west across Botswana and South Africa and ultimately to the Indian Ocean. This phenomenon has been designated the "River of Smoke". Such an episode was observed from 3 to 7 September 2000 during the intensive field campaign, and characterised by an array of airborne, ground based and satellite observations from TERRA and SeaWifs. Results will be presented on the horizontal and vertical properties of the River of Smoke plume, and aerosol properties. A similar episode during from 21 to 27 August 2001 has been captured by MODIS.

A42B-05 1430h

Aircraft observations of the physical and radiative properties of biomass aerosol particles during SAFARI-2000.

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An initial analysis will be shown from the ∼80 h of data collected between 2–18 September 2000 by the UK Met Office C-130 aircraft during the dry season campaign of the Southern African Regional Science Initiative (SAFARI-2000). The talk will concentrate on the physical and optical properties of the biomass aerosol. The evolution of the particle size spectrum and its optical properties at emission and after ageing will be shown. The vertical distribution of the biomass plume over the land and sea will be compared in view of the local meteorology. A generalised three log-normal model is shown to represent aged biomass aerosol over the sea areas, both in terms of the number and mass particle size spectra, but also derived optical properties (e.g. asymmetry factor, single scatter albedo (ω_0) and extinction coefficient) as calculated using Mie theory and appropriate refractive indices.

ω_0 was determined independently using a particle soot absorption photometer (giving the absorption coefficient at a wavelength of 0.567 μm) and a nephelometer (giving the scattering coefficients at 0.45, 0.55 and 0.65 μm). Good agreement was found between the measurements and those obtained from the Mie calculations and observed size distributions. A typical value of ω_0 at 0.55 μm for aged biomass aerosol was 0.90. The radiative properties of the biomass aerosol over both land and sea will be summarised.

Stratocumulus cloud was present on some of the days over the sea and the surprising lack of interaction between the elevated biomass plume (containing significant levels of cloud condensation nuclei) and the cloud capping the marine boundary layer will be illustrated. Using the cloud-free and cloudy case studies we can begin to elucidate the levels of direct and indirect forcing of the biomass aerosol on a regional scale.

URL: http://www.mrfnet.demon.co.uk/africa/SAFARI2000.htm

A42B-06 1445h

Particle and Gas Emissions From a Savanna Fire From Biomass Burning in Southern Africa

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Airborne measurements of the emissions of particles and gases from a 1000 ha prescribed savanna fire in the Timbavati Game Park, South Africa, were obtained on September 7, 2000, during the Southern African Fire-Atmosphere Research Initiative 2000 (SAFARI-2000) field study. These measurements provide enhancement ratios and emission factors at various points downwind of the fire for a number of gaseous and particulate species, including CO_2, CO, SO_2, NO_x, methane, non-methane hydrocarbons, halocarbons, organic acids, ionic aerosol, organic aerosols, and condensation nuclei (CN). The structure of the plume is revealed by profiles of CN concentrations and light scattering along the length of the plume. The decay of reactive hydrocarbons and the complementary formation of formaldehyde, ozone, and acetic acid are shown downwind of the fire. Aerosol size distributions show increases in concentrations of particles greater than 0.1 μm in diameter with increasing distance from the fire. As the fire aged, emission factors of CO_2 decreased while those of CO increased, indicating a shift from flaming to smoldering combustion. Vertical profiles of trace gases show peaks in water vapor, SO_2, O_3, and CN beneath strong temperature inversions above the fire.

URL: http://cargsun2.atmos.washington.edu/sys/research/safari/

A42B-07 1520h

Individual Aerosol Particle Types Produced by Savanna Burning

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We used analytical transmission electron microscopy (TEM) to study individual aerosol particles that were collected on the University of Washington Convair-580 research aircraft over southern Africa during the Safari2000 Dry Season Experiment. Our goals were to study the compositions, morphologies, and mixing states of carbonaceous particles, in order to better understand the physical and chemical properties of biomass smoke on the individual-particle level. The compositions of single particles were determined using energy-dispersive x-ray spectrometry (EDS) and electron energy-loss spectroscopy (EELS). Energy-loss maps obtained with the TEM are useful for studying the spatial distribution of light elements such as carbon within the particles; thus, they provide a detailed picture of complex particles.

Carbonaceous particles were assigned into three main groups on the basis of morphology and composition: "organic particles with inorganic inclusions," "tar balls," and "soot." Soot is recognized by its characteristic morphology and microstructure. The distinction between "organic particles with inorganic inclusions" and "tar balls" is somewhat arbitrary, since the two criteria that are used for their distinction (composition and aspect ratio) change continually. The relative concentrations of the three major particle types vary with the type of fire and distance from fire. In the plume of a smoldering fire west of Beria (August 31) the relative concentration of tar balls increased with aging of the plume. Tar balls have a fairly narrow size distribution with a maximum between 100 and 200 nm (diameter). The inorganic K-salt inclusions (KCl, K_2SO_4, KNO_3) within "organic particles" should make these particles hygroscopic, regardless of the properties of the organic compounds. Aging causes the conversion of KCl into K_2SO_4, KNO_3. Aerosol production from flaming and smoldering fires was compared over Kruger National Park on August 17; more soot and more Cl-rich inclusions in organic particles were produced by the flaming fire than by the smoldering fire. Further sets of samples from other flights of Safari2000 are being studied.

A42B-08 1535h

Southern African Haze During the SAFARI 2000 Field Campaign

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We have conducted extensive airborne experiments to measure the chemical composition of Southern African haze from September 12 to September 24, 2001. Ten missions were flown on the South Africa Weather Bureaus Aerocommander 690-A between 15 degrees S and 25 degrees S from the east coast of Mozambique to Etosha Pan in Namibia. More than 200 canister samples were collected and analyzed for carbon dioxide, carbon monoxide, hydrogen, and methane concentrations. The samples were collected from smoke plumes close to active fires, regional haze mixtures primarily containing aged smoke from distant fires, vertical profiles above NASA Aeronet automatic sun photometer sites, and background air near the plumes, above the boundary layer and off the eastern coast. A real-time instrument system was also used to measure carbon dioxide concentrations and aerosol light scattering with a nephelometer. We will present emission ratios, combustion efficiencies, and emission factors of carbon dioxide, carbon monoxide, and methane for the biomass smoke in arid savannas over this region of Africa. These results will be compared with the results from previous missions over the moist savannas of Zambia.

A42B-09 1550h

Cloud Physics Lidar Measurements During the SAFARI-2000 Field Campaign

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A new remote sensing instrument, the Cloud Physics Lidar (CPL) has been built for use on the ER-2 aircraft. The first deployment for CPL was the SAFARI-2000 field campaign during August-September 2000. The CPL is a three-wavelength lidar designed for studies of cirrus, subvisual cirrus, and boundary layer aerosols. The CPL utilizes a high repetition rate, low pulse energy laser with photon counting detectors.

In this presentation a brief description of the CPL instrument will be given, followed by examples of CPL data products. In particular, examples of aerosol backscatter, including boundary layer smoke and cirrus clouds will be shown. Resulting optical depth estimates derived from the aerosol measurements will be shown. Initial results of the optical depth calculations show significant differences between the 532 nm and 1064 nm boundary layer calculations, presumably due to heavy smoke in the boundary layer. Comparisons of the CPL optical depth and optical depth derived from MicroPulse Lidar and the AATS-14 sunphotomer will be shown.

A42B-10 1605h

Coordinated airborne, space borne, and ground based measurements of massive, thick haze layers during the SAFARI-2000 Dry Season Campaign

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From August 13 to September 25, the Southern African Regional Science Initiative's (SAFARI 2000) dry-season airborne campaign coordinated ground-based measurement teams, multiple research aircraft, and satellite overpasses across nine African nations. Among many others, unique coordinated observations were made of the evolution of massive, thick haze layers produced by biomass burning, industrial emissions, marine and biogenic sources.

The NASA Ames Airborne Tracking 14-channel Sunphotometer (AATS-14) was operated successfully aboard the University of Washington CV-580 during 24 data flights. The AATS-14 instrument measures the transmission of the direct solar beam at 14 discrete wavelengths (354-1558 nm) from which we derive spectral aerosol optical depths (AOD), columnar water vapor (CWV) and columnar ozone. Flying at different altitudes over a fixed location allows derivation of layer AOD and CWV. Data taken during feasible vertical profiles allows derivation of aerosol extinction and water vapor density.

In the talk, we show comparisons with ground-based AERONET sun/sky photometer results, with ground based MPL-Net lidar data, and with measurements from a lidar (CPL) aboard the high-flying ER-2 aircraft. We will use measurements from the Ames Solar Spectral Flux Radiometer to derive estimates of solar spectral forcing as a function of aerosol thickness. Validations of MODIS, MISR and TOMS satellite aerosol and water vapor retrievals will also be presented.

A42B-11 1620h

Airborne FTIR Measurements Obtained Aboard the UW CV-580 During SAFARI-2000

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The University of Montana/Forest Service airborne FTIR (AFTIR) was installed on the University of Washington Convair-580 for 19 flights between 14 August and 14 September 2000. We quantified the major trace gases in minutes-old biomass burning smoke (namely CO2, CO, CH4, C2H4, C2H2, CH2O, CH3OH, CH3COOH, HCOOH, NH3, NO, NO2, and HCN) from 9 fires in both arid and humid, wooded savannas where most global biomass burning occurs. Several of these measurements coincided with TERRA/ER2 overpasses. The AFTIR fire measurements confirmed the importance of oxygenated organic compounds in tropical smoke and provided an emission factor for HCN (a potential biomass burning tracer) that is 20 times higher than previously thought. AFTIR also documented some rapid post-emission chemical transformations in smoke. We measured actual formation rates for ozone and acetic acid in smoke downwind from two savanna fires. The ratio of excess ozone to excess CO reached 9% after a few hours of photochemical processing. The similar ratio for acetic acid increased from 1.4 to approximately 5% over the same time period. We observed cloud scavenging of methanol, ammonia, and acetic acid from smoke and a simultaneous, cloud-related source of formaldehyde in the plumes from two other savanna fires. To our knowledge, the SAFARI-2000 flights provided the first comprehensive characterization of savanna fire smoke samples with explicitly known smoke ages and post-emission processing scenarios. We also measured vertical profiles for CO2, CO, CH4, and H2O under TERRA/ER2 at 5 locations in the southern African gyre, one location in the continental outflow over the Atlantic, and one location in the inflow adjacent to the Indian Ocean. During a 3-aircraft intercomparison we observed trace gas enhancement in the free troposphere due to deep cumulus convection. Finally, we measured high NOx emission factors for ships off Namibia. Taken together, our FTIR-based measurements of the emissions from ships, savanna fires, the production and use of biofuels, and the related structure of the African, dry-season troposphere could contribute substantially to global atmospheric chemistry models.

A42B-12 1635h

Multi-Platform Haze Layer Characterization for the Eastern Coastal Region of Southern Africa during SAFARI 2000

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As part of the Southern African Regional Science Initiative (SAFARI 2000) Third Intensive Campaign, two South African Weather Service research aircraft flew missions with the objective to capture trace gas and aerosol characteristics for a variety of pyrogenic, biogenic, and industrial emissions. Coastal research flights were conducted off the southern African coastline covering an area from approximately Richards Bay, South Africa to Maputo, Mozambique. Vertical profiles were conducted in the vicinity of Inhaca Island, Mozambique, which served as a SAFARI 2000 and AERONET validation site. These profiles consisting of aircraft measurements of O3, SO2, CO, NO, aerosol concentrations, and size distributions indicate the presence of distinct elevated layers of trace gases and aerosols. The profiles are presented in conjunction with synoptic meteorological data to understand the controls that atmospheric circulation patterns exert on haze layers with respect to horizontal extent, transport and vertical structure. Comparisons of in-situ data obtained by aircraft instrumentation with ground-based AERONET data and with remotely-sensed aerosol products are used to identify possible biases in remotely-sensed retrieval methods.

A42C MC: 133 Thursday 1330h

Bjerknes Lecture

A42C-01 1335h

Testing Cloud Parameterizations Used in Climate Models Against Observations and High-Resolution Cloud Models

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Cloud feedbacks are the single greatest unknown limiting the credibility of simulations of anthropogenic climate change. Current research is aimed at evaluating the physical realism of the cloud parameterizations used in climate models. These evaluations are of course fundamentally based on comparison with observations, including both field data and satellite data. In addition,results from high-resolution cloud models are being combined with observations to provide more stringent tests of cloud parameterizations. This paper will summarize recent work in this area, with emphasis on the evaluation of models through the use of observations obtained through the U.S. Department of Energy's ARM ("Atmospheric Radiation Measurements") Program. We will also discuss recent suggestions by W. Grabowski and others that the high-resolution cloud models can themselves be used as "super parameterizations" within climate models.

A42D MC: 133 Thursday 1445h

Tropospheric Chemistry and Constituents I

Presiding: **A Volz-Thomas,** Forschungszentrum Juelich, Institut fuer Chemie und Dynamik der Geosphaere II; **J Lamarque,** NCAR

A

A42D-01 1445h

Development and Evaluation of Uniform- and Stretched-grid Versions of the University of Maryland Chemical Transport Model

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We have developed the 3-D global University of Maryland Chemical Transport Model (UMD-CTM) with a stretched-grid feature which allows transport and chemistry to be computed with mesoscale resolution in a region of interest. The model contains the stretched-grid transport algorithm of Allen et al. (2000) and the SMVGEAR II chemical solver, as well as convective transport, eddy diffusion, emission, dry deposition, wet scavenging, and stratospheric influx schemes. The model was first assembled with a uniform grid, run for a complete year, and evaluated with a variety of surface, airborne, and sonde observations. For most species no systematic biases were found in the model results, allowing us to proceed with the stretched-grid version and with applications to investigate the roles of various factors controlling tropospheric chemistry. Park et al. will present results of the stretched-grid UMD-CTM for a series of convective episodes over the central U. S.

A42D-02 1500h

Deep Convection and Its Chemical Consequences over the Central U. S. in a Stretched-grid Chemical Transport Model

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The stretched-grid version of the University of Maryland Chemical Transport Model (UMD-CTM) has been run for the June 1985 period of the Kansas/Oklahoma PRESTORM deep convection field program. The model is driven by assimilated meteorological data from the stretched-grid version of the GEOS-3 DAS. Horizontal resolution is uniformly 0.5 deg. over the central U. S., stretching to a maximum grid size of about 4 deg. on the opposite side of the globe. We examine particular case study convective events in terms of how well the convection is represented in the model and through comparisons of model output with measured trace gas species such as CO, NO, and ozone. Comparison of the model output with mean profiles of airborne measurements for three flow regimes was also performed. The magnitude of the enhancement of photochemical ozone production in the upper troposphere over the central U. S. following major convective events is examined.