LIST OF PRESENTATIONS and ACCOMPANYING ABSTRACTS

Monday October 7, 2001

Relevance of SAFARI 2000: Science to National and International Program Goals

09:00 – 09:10
Official Welcome to the University of Virginia/Opening of the Synthesis Workshop
Prof. Gene Block, Provost, University of Virginia

09:10 – 09:30
SAFARI 2000 – Past, Present, Future
Asst. Prof. Robert J. Swap, University of Virginia

09:30 – 09:50
Relevance of SAFARI 2000 to the NASA ESE
Dr. Diane Wickland, NASA HQ and *Prof. Chris O. Justice*, University of Maryland

09:50 – 10:10
Relevance of SAFARI 2000 to South Africa's National Research Foundation, the Department of Arts, Culture, Science and Technology
Prof. Harold Annegarn, University of the Witwatersrand and *Dr. Bob Scholes*, CSIR

10:10 – 10:40
Special Invited Address
Relevance of SAFARI 2000 to Regional Environmental Policy in Light of the WSSD and the African Process, the Hon. Deputy Minister of Environmental Affairs and Tourism from the Republic of South Africa and the Chair of the African Process
Ms. *Rejoice Mabudafhasi*

Aircraft Science to Date

11:00 – 11:20
The NASA ER-2
Dr. Michael D. King, NASA GSFC

11:20 – 11:40
Vertical profiles of light scattering, light absorption and single-scattering albedo during the dry, biomass burning season in southern Africa and comparisons of in situ and remote sensing measurements of aerosol optical depths
B. I. Magi, P. V. Hobbs, B. Schmid and J. Redemann

Abstract
Airborne in situ measurements of vertical profiles of aerosol light scattering, light absorption and single-scattering albedo (ω_0), obtained aboard the University of Washington's Convair-580, are presented for a number of locations in southern Africa during the dry, biomass-burning season. Features of the profiles include haze layers, clean air slots, and marked decreases in light scattering in passing from the boundary layer into the free troposphere. Frequency distributions of ω_0 reflect the strong influence of smoke from biomass burning. For example, during a period when heavy smoke was advected into the region from the north (the "River of Smoke" episode), the mean value of ω_0 in the boundary layer was 0.83 ± 0.02, compared to 0.90 ± 0.03 prior to this intrusion. Comparisons of aerosol optical depths derived from the in situ measurements with those measured by a Sunphotometer aboard the Convair-580 show the best agreement yet obtained in such "closure studies."

11:40 – 12:00

Key findings from the UKMO C-130 during SAFARI 2000

J. Haywood, P. Formenti, A. Keil and G. Myhre

Abstract

This synthesis report incorporates the main findings from 5 studies performed by MRF and associated groups during SAFARI-2000. These studies have been submitted to the Journal of Geophysical Research SAFARI-2000 Special Issue, and all are accepted for publication. The titles and abstracts are listed below:

1) Inorganic and organic aerosols during SAFARI 2000: Chemical characteristics, physical properties, and emission data for smoke from African biomass burning

P. Formenti, W. Elbert, W. Maenhaut, J. Haywood, S. Osborne, and M. Andreae

We collected filter samples of the atmospheric aerosol during the Southern African Regional Science Initiative experiment (SAFARI 2000) onboard the U.K. Met Office C-130 aircraft. The main operational area was the Atlantic Ocean offshore of Namibia and Angola, where biomass-smoke haze at least one-two days old was widespread. The size-fractionated aerosol samples were analyzed for the major water-soluble ions, carbonaceous material (elemental and organic carbon), and elements with atomic numbers between Na and Pb. The regional haze was composed by carbonaceous aerosols (in average accounting for 81% of the submicron mass) and secondary inorganic aerosols (sulfate, ammonium, and nitrate) by 14%. K^+ and Cl^-, typical pyrogenic inorganic ions, constituted only 2% of the mass. The aerosol chemical data were used to estimate mass emission fluxes for various aerosol components. For African savanna/grassland burning, the estimated emission flux of carbonaceous particles (organic plus elemental) is 0.35 ± 0.24 Tg yr^{-1}, and that of the nitrogen species (nitrate and ammonium) is 0.11 ± 0.08 Tg yr^{-1}. For the flight segments in regional haze, the mean particle scattering coefficient at 550 nm was ? $_s$ = 101 ± 56 Mm^{-1} and the mean particle absorption coefficient ? $_a$ at 565 nm averaged 8 ± 5 Mm^{-1}. The dry mass scattering efficiency ? $_s$, calculated from the linear regression of the mean scattering vs. the estimated submicron mass, is estimated to vary between 4.2 ± 0.8 m^2 g^{-1} and ? $_s$ = 4.6 ± 0.6 m^2 g^{-1}, depending on the assumptions made in calculating the aerosol mass. Looking at the longitude dependence of the scattering enhancement ratios ? ? $_s$/? CO suggests the evolution of particle size with time influences the amount of scattered light. Fresh smoke was sampled during a dedicated flight in the proximity and within the plume of an active biomass burning fire. Here the enhancement ratio with respect to CO of particles in the Aitken-size range (5–100 nm diameter) was ? N_{Aitken}/? CO ~ 25 cm^{-3} (STP) ppb^{-1}. These particles were removed rapidly after emission, and were not detectable in the regional haze. The enhancement ratio for accumulation mode particles (0.1–1 ? m diameter) ? N_{Acc}/? CO was ~ 26–30 cm^{-3} (STP) ppb^{-1} in young smoke, and 16 ± 3 cm^{-3} (STP) ppb^{-1} in aged haze, suggesting that about 41% of the accumulation mode particles was removed by during aging.

2) The mean physical and optical properties of regional haze dominated by biomass burning aerosol measured from the C-130 aircraft during SAFARI 2000

J. Haywood, S. Osborne, P. Francis, A. Keil, P. Formenti, M. Andreae, and P. Kaye

Instrumentation on the Met Office C-130 aircraft measured the properties of aerosol during SAFARI-2000. Filter measurements of aged regional haze suggest a ratio of apparent elemental carbon (EC_a) to organic carbon (OC) of 0.12±0.02, and mass fractions of 5% EC_a, 25% inorganic compounds, and 70% organic matter (OC plus associated elements). The sub-micron size distribution of aged regional haze is similar throughout the period, and may be fitted with three log-normal distributions with geometric mean radii, r_n, of 0.12±0.01µm, 0.26±0.01µm, and 0.80±0.01µm and standard deviations, ? ∂f 1.3±0.1, 1.5±0.1, and 1.9±0.4. Measurements over 2500 km from the emission region show similar r_n and ? for the first two modes while the third mode is absent presumably because of sedimentation. At 0.55µm, effective medium approximations suggest a refractive index of 1.54-0.018i for aged aerosol. ? $_o$ derived using this refractive index and the measured size distributions are consistent with those from the nephelometer and Particle Soot Absorption Photometer. The derived optical parameters for aged aerosol at 0.55 µm are k_e=5 m^2 g^{-1}, g=0.59 and ? $_o$=0.91 for aged aerosol. Measurements in a fresh biomass plume show smaller particles, and a smaller EC_a/OC mass ratio of 0.08. Vertical profiles of CO, aerosol concentration and scattering show a good correlation, and suggest that the aerosols become well-mixed over land regions. Over ocean, the aerosols can be separated from underlying strato-cumulus (Sc) cloud by a clear-gap and a strong inversion, which may inhibit the mixing of biomass aerosol and Sc thereby limiting the indirect effect.

3) Comparison of aerosol size distributions, radiative properties and optical depths determined by aircraft observations and sunphotometers during SAFARI-2000

J. Haywood, P. Francis, O. Dubovik, M. Glew and B. Holben

The Met Office C-130 aircraft performed a dedicated flight over the Etosha Pan surface based AERONET sun-photometer site on September 13, 2000 during the SAFARI-2000 intensive measurement campaign. Aerosol optical depths at different wavelengths, $?_{aer?}$, are derived from in-situ measurements of the scattering and absorption coefficients, and from various radiometric measurements and compared to those derived from the sun-photometer site. The estimates of $?_{aer?}$ from the various measurements are shown to be in good agreement. The exception to this is when $?_{aer?}$ is derived from the PCASP as this method is shown to be extremely sensitive to the pitch angle of the aircraft and therefore $?_{aer?}$ differs for profile ascents and profile descents. However, the aerosol size distribution measured by the PCASP and derived from the AERONET site are in excellent agreement over the 0.05-1.0 μm radius range, which contains the majority of the optically active particles. C-130 derived refractive indices and single scattering albedos are also shown to be in excellent agreement with those derived from the AERONET site. These results suggest that, for aerosol well-mixed in the vertical, data from AERONET may be used with confidence in validating satellite measurements and modelling studies of the radiative properties and effects of aerosols.

4) Solar Radiative Forcing by Biomass Burning Aerosol Particles in Cloudy Skies during SAFARI-2000

A. Keil and J. Haywood

This study investigates the overall sign and magnitude of the top of the atmosphere (TOA) solar radiative forcing by biomass burning aerosol from the African continent. Based on airborne measurements of aerosol and cloud parameters, representative for the SAFARI-2000 campaign, we focus on how the radiative effects of biomass aerosol are changed in the presence of marine clouds to the west of the southern African coast line. The typical scenario, observed during the campaign, showed a clear separation between an elevated biomass burning aerosol layer (1.8-3.7 km altitude for the case investigated here) and low level stratiform clouds (located below 1 km altitude). The aerosol was characterized by particle number concentrations of 1800 cm^{-3}, an aerosol scattering coefficient of 7×10^{-5} m^{-1} and a single scattering albedo of around 0.9 (varying between 0.86 and 0.93 throughout the campaign). The observed clouds had a mean liquid water path (LWP) of around 80 gm^{-2}, drop number concentrations of up to 210 cm^{-3} and drop effective radii between 8 and 10 μm. Presuming no effect by the biomass aerosol on the clouds themselves (i.e. no indirect aerosol effect), the presence of the clouds converted the strong negative TOA forcing by the biomass aerosol in clear skies into a strongly positive one. Including clear sky and cloudy conditions, the calculations showed a variation of the local TOA direct solar radiative forcing by the biomass aerosol between -13 and +11.5 Wm^{-2} for average aerosol characteristics. On a climatic scale one can expect positive TOA forcings in extended sea areas over the Namibian cloud sheet during the major biomass burning season. Additionally, we estimate the possibility that the potential indirect effect dominates the overall forcing, resulting generally in a strong negative TOA forcing, and discuss surface forcings as well as changes in heating rates due to biomass aerosol.

5) Modelling the solar radiative impact of aerosols from biomass burning during SAFARI-2000

G. Myhre, T. Berntsen, J. Haywood, J. Sundet, B. Holben, M. Johnsrud, F. Stordal

In this study we model the radiative impact of biomass burning aerosols with meteorological data for the SAFARI-2000 campaign period. Satellite, ground based, and aircraft observations are used in validation of the modelled aerosol optical depth (AOD), vertical profiles, and radiative impact of the aerosols. The modelled pattern and magnitude of the AOD is in generally good agreement with the observations. The meteorological conditions are found to be important for determining the distribution of the aerosols. The modelled radiative impact of the biomass aerosols compares well to measurements. During September 2000 the modelled radiative impact of biomass aerosols reaches -50 W m^{-2} locally.

12:00 – 12:20

SAWS Aerocommanders during SAFARI 2000: Some preliminary findings

S.J. Piketh, University of the Witwatersrand

Afternoon Session Plenary: Examples of SAFARI Science Synthesis Components

13:45 – 14:00

APINA activities towards development of a regional policy on air pollution in southern Africa

S. Simukanga, A. M. van Tienhoven, B. Chipindu and K. Hicks

Abstract

The increasing threat of air pollution in Southern Africa and the consequent rise in the concentration of pollutant gases and acid deposition will have serious implications for human health, the functioning of ecosystems and corrosion of materials. Even countries that do not have high emissions of pollutants may be affected by the impacts of pollution advected by wind across national boundaries (Transboundary Air Pollution). To address the issues related to air pollution, a regional network of scientists, policy-makers and non-governmental organizations, known as the Air Pollution Information Network for Africa (APINA), was established in 1997. Similar networks have been established in Asia (APINAP) and Latin America (APINLA). This forms part of a Programme on Atmospheric Environment Issues in Developing Countries coordinated by the Stockholm Environment Institute (SEI) and funded by the Swedish International Development Cooperation Agency (Sida) under a project entitled "Regional Air Pollution in Developing Countries (RAPIDC). APINA is coordinated through the Institute of Environmental Studies (IES) of the University of Zimbabwe. IES carries out research through "Associates" who are affiliated to the institute. Currently the APINA coordinator is Prof. Stephen Simukanga based at the School of Mines, University of Zambia. Contact persons for a number of SADC countries form a committee of country representatives for APINA through whom country activities are coordinated. The main role of APINA is to form a strong link between the air pollution scientific community and policy makers at national and regional levels. It acts as a conduit of knowledge and data derived in the scientific programmes and existing research to influence policy and decision-makers in matters related to air pollution. APINA acts as a link between different networks and programmes on air pollution in Africa. In this presentation some activities that APINA has undertaken since its inception in 1997 are outlined together with its programme up to 2004.

14:00 – 14:15

Channelling SAFARI 2000 results for developing regional policy on the environment for southern Africa

J. J. Cumbane, A. M. van Tienhoven, S. Simukanga, B. Chipindo and K. Hicks

Abstract

Substantive scientific evidence has been produced indicating that southern Africa is undergoing environmental change at a fairly accelerated pace. This change is spurred by population growth and industrial development following the end of civil wars and political strife in the region. Though the relevant consequences of the observed change have not been conclusively established, the mechanisms physically linking the region's atmosphere, lithosphere, hydrosphere and biosphere confer to this change a regional extent, with no respect for state boundaries. The pattern of these mechanisms has been shown to be predictable, which provided the rationale for the concept of the Southern African Regional Science Initiative (SARAFI 2000) to investigate on the coupled land-atmosphere processes associated with the emission, transport, transformation, deposition and impact of atmospheric aerosols and trace gases in southern Africa. Through its core experiment, SAFARI 2000 has succeeded in gathering environmental data that will help improve current scientific understanding of the region's physical, chemical and biological system interactions. In particular, data from SAFARI 2000 will provide an insight into current regional environmental change in response to human activities. However, until recently the quest for an improved scientific understanding of environmental problems in southern Africa was not paralleled by the development of appropriate regional policy to cope with the observed environmental change. The lack of appropriate conduit of scientific knowledge for policy formulation has been identified as the major constraint faced in this process. Accordingly, paralleling the launch and implementation of SAFARI 2000, the Air Pollution Information Network for Africa (APINA) was created that sets to bridge the gap between scientific research and policy formulation process in southern Africa. SAFARI 2000 has recognised APINA as a means of transferring scientific information on air pollution issues to the policy development process in the region. This paper reports on the progress of APINA and presents a possible framework for channelling SAFARI 2000 findings to the development of a needed regional charter on long-range transboundary air pollution for the region.

14:15 – 14:30

Zambia's participartion in Southern African Regional Science Initiative (SAFARI 2000). A summary of activities

M. Mukelabai, J. L. Privette, J. Kanyanga, R. J. Swap and R. Mugara

Abstract

The SAFARI 2000 activities in Zambia builds on the success of the Zambian International Biomass Burning Emissions Experiment (ZIBBEE). The ZIBBEE took place in August to September 1997 with the primary objective of quantifying the aerosol and trace gas fluxes from the savannas and woodlands of southern Africa. SAFARI 2000 on the other hand started its activities in Zambia in 1999. Its aim was to develop a better understanding of the earth-atmosphere-human system in southern Africa. The Zambia Meteorological Department (ZMD) in the Ministry of Communications and Transport is the focal point for both activities in Zambia. Arising from the ZIBBEE and SAFARI 2000, long-term aerosol measurements have been taken since 1995 while canopy and radiation measurements begun in 2000 after the erection of a 30m high meteorological flux tower in Kataba local forest (south of Mongu, Zambia).SAFARI 2000 intensive field campaigns were carried out in Zambia during both the wet season (February/March) and the dry season (August/September) of 2000. These periods were deliberately chosen to target the periods of maximum vegetation cover (during the wet season) and biomass burning (during the dry season). The wet season campaign was successfully accomplished while the dry season campaign was prematurely aborted due to administrative technicalities with the Zambian government. Notwithstanding the premature abortion of the dry season SAFARI 2000 campaign, the Zambian government offered to host the First SAFARI 2000 Data Workshop in August 2001.The First SAFARI 2000 Data Workshop was held in Siavonga, Zambia from 28 to 31 August 2001. The Permanent Secretary, Ministry of Environment and Natural resources through her officials was the guest of honor at both the opening and closing ceremony of the Workshop. The Workshop brought together regional and international scientists and postgraduate students in the fields of environmental, atmospheric and space technology research.

14:30 – 14:50

Data coordination and distribution by NASA's SAFARI data team

J. E. Nickeson, D. L. Landis, J. L. Privette and J. T. Morisette

Abstract

NASA's SAFARI 2000 Data Team was formed in 2000 to help coordinate and distribute data to SAFARI participants worldwide. Besides helping to formulate the SAFARI registration and data submission approaches, this group has actively coordinated the acquisition of satellite data sets and data publication. The group has coordinated the production and distribution of two volumes of data on CD-ROM, largely containing operational and aircraft data sets. The final activity of this group will be a third CD-ROM volume tentatively scheduled for release in late 2003. The contents of the final volume will primarily include data sets collected in the field by participants of the wet season focused field campaigns along the Kalahari Transect in 2000 and at the Maun and Skukuza sites in 2001. This volume will also contain any updates of data sets from the earlier volumes, as well as SAFARI data not previously available. The Volume 3 CD-ROM will be the final opportunity for SAFARI participants to submit data for CD-ROM publication. The NASA Data Team is one component of the SAFARI 2000 Data Group, which also includes participants from the University of the Witwatersrand, the South African National Disaster Management Center (NDMC), the Oak Ridge National Laboratory's DAAC, and the University of Virginia. The complete SAFARI archives will reside at the NDMC and the ORNL DAAC.

14:50 – 15:10

Implementation of the integrated information technology at the National Disaster Management Centre: Relevance to SAFARI 2000

D. Sakulski and R. Weinmann

Abstract

The South African National Disaster Management Centre (NDMC) is amassing one of the largest collections of historic and real-time environmental related data for southern Africa. This constantly improving resource has substantially benefited the SAFARI 2000 program, and is available to the entire NASA earth science research community at no cost through an open WWW interface. One of the main tasks of the South African NDMC is coordination. Horizontally, amongst National Departments (Water Affairs, Agriculture, Health, etc), SAPS, SANDF, Weather Services, Universities. Vertically, amongst Provincial Disaster Centres, Regional and/or Metro Disaster Centres and Municipalities. To be able to fulfill that function, NDMC acts as an information exchange hub. NDMC initiative is to shift from the post-disaster activities (mitigation) towards prevention, as much as possible. Main focus is on development and implementation of the integrated information technology to support prevention

and decision-making at the NDMC. Various hardware, software, as well as technical solutions are in use at the NDMC. The aim of this seminar is to highlight ongoing development.

15:10 – 15:25
Metadata Collection and Archiving
R. B. Cook

15:45 – 16:00
Validation of the MODIS LAI and FPAR Products and their relationship to canopy structure along the southern Africa Kalahari transect
J. L. Privette, M. Mukelabai, K. F. Huemmrich, R. B. Myneni and Y. Knyazikhin

Abstract
We evaluated the operational MODIS Leaf Area Index (LAI) and Absorbed Photosynthetic Radiation (FPAR) products using field-measured data collected at five sites in southern Africa in March 2000. One site (Mongu, Zambia) was sampled monthly throughout the year. All sites were along the IGBP Kalahari Transect, which features progressively lower annual precipitation, and hence lower vegetation productivity, from north to south. At each site, we sampled the vegetation overstory along three 750 m transects using the Tracing Radiation and Architecture in Canopies (TRAC) and LAI-2000 instruments. The resulting plant area index (PAI) values were adjusted with ancillary stem area data to estimate LAI, and compared to the MODIS products. Results show that fractional canopy cover and PAI increase, and overstory clumping decreases, with increasing annual precipitation. Empirical relationships are provided relating these parameters to each other and to precipitation. Our results also suggest the MODIS LAI algorithm accommodates structural and phenological variability in semi-arid woodlands and savannas, and is numerically accurate to within the field measurement uncertainty.

16:00 – 16:15
Emissions and evolution of trace gases and particles from savanna fires in southern Africa
P. Sinha, P. V. Hobbs, R. J. Yokelson, I. T. Bertschi, T. J. Christian, D. R. Blake, S. Gao, T. W. Kirchstetter, T. Novakov, and P. Pilewskie

Abstract
Measurements made aboard the University of Washington's Convair-580 aircraft in SAFARI 2000 provided quantitative information on the emissions of particles and gases from ten savanna fires in southern Africa. These measurements provide emission ratios and emission factors for fifty gaseous and particulate species, including carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, methane, ammonia, dimethyl sulfide, non-methane organic compounds, halocarbons, gaseous organic acids, aerosol ionic components, carbonaceous aerosols, and condensation nuclei. Emission factors were obtained for eight species that have not been reported previously for biomass burning of savanna in southern Africa (namely, dimethyl sulfide, methyl nitrate, five hydrocarbons, and particles with diameters from 0.1-3 μm diameter). Also the emission factor that we measured for a number of important species differ significantly from previous reports. Airborne measurements of particles and gases at various distances downwind from a 1000 ha savanna fire in South Africa (the Timbavati fire) were obtained aboard the University of Washington's Convair-580 in SAFARI 2000. These measurements represent the most extensive data set yet reported on the evolution with age of biomass smoke. The measurements include particle concentrations (CN) and sizes, particulate organic carbon and black carbon, light-scattering coefficients, downwelling-UV fluxes, and mixing ratios for forty-two trace gases and seven particulate species. The ratios of excess nitrate, ozone, and gaseous acetic acid to excess CO in the plume increased significantly as the smoke aged over ~40-45 min, indicating that these species were formed by photochemistry in the plume. For seventeen other species the excess mixing ratio normalized by the excess mixing ratio of CO decreased significantly with smoke age. The relative rates of decrease for a number of chemical species imply that the average OH concentration in the plume was ~1.7×10^7 molecules/cm^3. The excess concentration of CN, normalized by excess CO, decreased rapidly during the first ~5 min of aging, probably due to coagulation, and then subsequently increased, probably due to gas-to-particle conversion. The CO-normalized concentrations of particles <1.5 μm in diameter decreased, and particles >1.5 μm diameter increased, with smoke age.

16:15 – 16:30

Remote sensing observations of carbon monoxide in the '*River of Smoke*' on September 6, 2000 and comparisons to in-situ measurements

M. L. McCourt, W. W. McMillan, H. E. Revercomb, R. O. Knuteson, R. J. Yokelson

Abstract

The September 6, 2000, flight of the NASA ER-2 during SAFARI 2000 provided observations across the *river of smoke* in central Africa over eastern Botswana and western Zambia as well as an opportunity to compare remote sensing observations with *in situ* measurements. With infrared spectra acquired by the University of Washington-Madison Scanning High-resolution Interferometer Sounder (SHIS) flying onboard the ER-2, we utilize a Fourier signal processing technique for the 1-0 vibration-rotation band of CO centered near 2142 cm^{-1}, to retrieve total tropospheric column abundances of carbon monoxide along the flight track. The *river of smoke* is clearly delineated in our CO retrievals by tropospheric CO columns up to 5.7×10^{18} cm^{-2} while values near 3.6×10^{18} cm^{-2} are found on either side. These values off the *river of smoke* are enhanced over background air found on the flight of September 7, 2000 [McMillan et al., accepted to JGR S2K special issue]. The largest tropospheric CO values on this flight, 1.2×10^{19} cm^{-2}, were found in west central Zambia and are comparable to CO columns measured over the Timbavati fire on September 7, 2000. ER-2 flight tracks near Mongu airport were coordinated with other SAFARI 2000 aircraft including the University of Washington Convair-580 with the Airborne Fourier Transform Interferometer (AFTIR) onboard. Creating a CO profile from the AFTIR grab samples yields an *in situ* total column carbon monoxide amount of 4.7×10^{18} cm^{-2} which agrees well with our values of 4.17 to 5.17×10^{18} cm^{-2} retrieved from SHIS spectra obtained near Mongu airport. Comparisons of spatial and temporal variations in our CO abundances with maps of the Total Ozone Mapping Spectrometer (TOMS) Aerosol Index and aerosol profiles from the ER-2 based Cloud Physics Lidar (CPL) will be presented.

16:30 – 16:45

A Qualitative assessment of MODIS data for burned area mapping in Namibia

J. L. Le Roux and D. P. Roy

Abstract

Numerous studies related to the burning of biomass were conducted across Southern Africa as part of the SAFARI 2000 field campaign, and burned area products from a variety of satellite sensors are being developed by the remote sensing community. This study compares burned area products derived from NASA's MODerate resolution Imaging Spectroradiometer (MODIS), with an operational product produced from NOAA AVHRR HRPT data captured daily by Namibia's Etosha Ecological Institute. MODIS surface reflectance data at 250 and 500 meter resolution and AVHRR data at 1000 meter resolution, were used to produce burned area maps for a fire event that effected 13 commercials farms adjacent to the Etosha National Park. All three products are evaluated against surrogate ground data derived from Landsat ETM+ data as part of the Southern Africa Fire Network (SAFNet) validation of the MODIS regional burned area product. Results show the superiority of the MODIS product due to increased geolocational accuracy and higher spatial resolution. The importance of statements concerning the accuracy of burned area products are illustrated in economic terms, and implications for local level decision makers are discussed.

16:45 – 17:00

Lidar observations depicting tropospheric aerosol transport over South Africa during the ARREX and SAFARI-2000 experiments

J. R. Campbell, E. J. Welton, J. D. Spinhirne, Q. Ji, S. Tsay, S. J. Piketh, M. Barenbrug and B. N. Holben

Abstract

During the ARREX-1999 and SAFARI-2000 Dry Season experiments a Micropulse Lidar (523 nm) instrument was operated at the Skukuza Airport in northeastern South Africa. The lidar was co-located with a diverse array of passive radiometric equipment. From SAFARI-2000 the lidar data yield a daytime time-series of layer mean aerosol optical properties, including layer-mean extinction-to-backscatter ratios and vertical extinction cross-section profiles. Combined with aerosol optical depths and spectral Angstrom exponent calculations from available CIMEL Sun photometer data, normalized broadband flux measurements and calculated air mass back trajectories we discuss the temporal evolution of the surface aerosol layer optical properties and analyze potential climatological trends. For dense biomass smoke events the extinction-to-backscatter ratio is between 50 – 90 sr, and corresponding spectral Angstrom exponent values are between 1.50 and 2.00. We also examine two case studies. First, observations of an advecting smoke event during SAFARI-2000 are shown. The smoke was embedded within separate stratified thermodynamic layers causing the particulate mass to advect over the instrument array in an

incoherent manner on the afternoon of 1 September 2000. Significant surface broadband flux forcing of over –50 W/m^2 was measured in this event. The evolution of the vertical aerosol extinction profile is shown using the lidar data and surface all-sky imaging. Second, observations of persistent elevated aerosol layers during ARREX-1999 are presented and discussed. Back trajectory analyses combined with lidar and Sun photometer measurements indicate the strong likelihood for these aerosols being the result of long-range dust transport from the deserts of southern South America.

17:00 – 17:15

Integration of ground-based, remote sensed, and modelling activities related to biomass burning and emission estimates over southern Africa

C. Hély, S. Alleaume, K. K. Caylor, R. J. Swap and H.H. Shugart

Abstract

Fires in African savannas produce emissions contributing to changes in global biogeochemical processes. As part of the Southern African Regional Science Initiative (SAFARI-2000), we integrate ground-based, remote-sensed, and modelling activities in order to analyze biomass burning and estimate emissions from local to regional scales. During the 2000-wet season field campaign, parameters such as vegetation structure, leaf physiology data, Tree Cover, and grass biomass have been measured along the Kalahari transect ranging from closed –canopy forest in western Zambia Miombo woodland to open grasslands in South Africa. Two dry season field campaigns (2000 and 2001) in Zambia (western and northern regions) and in Namibia (Etosha National Park) have also been conducted to characterize vegetation structure and fuel types and loads over savannas presenting a gradient in canopy cover. Natural fires in Namibia and prescribed fires in western Zambia have been analyzed to relate fuel and weather conditions to fire behavior. Ground-based relationships such as combustion completeness as a function of Tree Cover, or Light Use Efficiency as a function of Precipitation and Tree Cover are derived at local and regional scales in order to build a spatially explicit regional fuel load model for the southern African savanna region. The model is based on a patch-scale Production Efficiency Model scaled up to the regional level using empirical relationships between patch-scale behavior and multi-source remote sensing data (spatio-temporal variability of vegetation through NDVI, radiation, and climatic variables). Processes such as Net Primary Production, litterfall, and herbivory are taken into account in this mechanistic modeling approach. This model has been calibrated from measurements recorded in 1995-97 along the Kalahari transect, and verified from independent site measurements of fuel loads recorded during the SAFARI 2000 dry season field campaigns and other past campaigns. Fuel load ranges predicted by the model are in agreement with previous field measurements. Consistently with previous studies, precipitation is recognized to be the major climatic driver for fuel production. The performance of the model is tested for two climatically contrasting years (1992 and 2000) over for 4 different areas representative of a regional rainfall gradient - Etosha National Park, Namibia, Mongu and Kasama, Zambia and Kruger National Park, South Africa. Within each area, model output from three different magnitudes of Tree Cover (<5, 30, and 50%) are analyzed. Even though there was a regional increase in precipitation in 1999-2000 as compared to the 1991-1992 periods, the temporal and spatial variability in precipitation at the site scale is important enough to restrict generalities over the entire region for fuel load production. The four areas present contrasting fuel load distributions for the two very different years with arid areas producing heavier fuel loads in 1999-2000, and the more humid areas producing heavier fuel loads in 1991-1992.Emissions from the main carbonaceous compounds (CO_2, CO, CH_4, NMCH and $PM_{2.5}$). are estimated for the SAFARI 2000 intensive study period (August and September 2000) for Africa south of the equator. The total burned area for this period is extracted from the monthly Global Burned Area product (GBA2000 at 1-km^2 resolution) from the SPOT-VGT-S1 satellite product. For each square kilometer burned, the amount of biomass burned is estimated relating the predicted fuel loads at 1-km^2 resolution from the fuel load model to the Combustion completeness-Tree Cover relationship. Published Emission factors from SAFARI-92 are also used to compile the emission estimates. Over August and September 2000, 31067 fires detected by the SPOT satellite are calculated to have emitted 96.9 10^{12}g of CO_2, 4.6 10^{12}g of CO, and lesser amounts of CH_4, NMCH, and $PM_{2.5}$. These calculations are in the range of previous estimates of the emissions of these compounds for southern Africa.

Poster Session in Clark Mural Room
Two-minute presentations by each lead author starting at 17:30

Seasonal variability of aerosol single scattering albedo at biomass burning sites in southern Africa and Amazonia
T. F. Eck, B. N. Holben, M. M. Mukelabai, O. Dubovik, A. Smirnov, J. S. Schafer and I. Slutsker

Seasonal and inter-annual carbon & water dynamics of savanna systems in southern Africa
N. P. Hanan, R. J. Scholes and J. L. Privette
Abstract
Eddy covariance measurements of CO2, water and energy fluxes have been made at a site in the Kruger National Park (KNP), South Africa, since April 2000. The study site is located in the southern region of KNP in a gently undulating landscape on granite substrate, with drainage lines 2-3 km apart and ridge tops 30-40 meters above the valley floors. The climate is semi-arid subtropical, with hot, rainy summers, warm dry winters and annual average rainfall of 550-650 mm. Soils vary between coarse-textured sand near the ridge-tops and finer-textured loamy-sand on the mid-slope and valley floors, with broad-leaved tree species and low palatability grasses on the sandy soil and bi-pinnate tree species and more palatable grasses on the loam soils. The natural disturbance regime of the site includes fire at a nominal return interval of 3-8 years, although fires have burned the area of the tower in both 2000 and 2001 dry seasons thus far. Grazing and browsing by numerous species of wild ungulates removes a variable proportion of net primary production, depending on species and location. Results from the first three years of measurements are presented, and discussed in relation to the functional and phenological differences between broad-leaf and fine-leaf savanna and seasonal and inter-annual variations.

The impact of land use on the belowground carbon budget of the Miombo woodlands region
S. Walker and P. Desanker
Abstract
In the Miombo Woodlands Region of south-central Africa, it is estimated 50-80% of the total system's carbon stock is found in the top 1.5 m belowground. Human population pressure in south-central Africa, with rising demand for productive soils causes increasing deforestation and land degradation. We studied soil carbon stocks within the miombo woodlands region to understand alterations in soil carbon levels caused by each dominant land use: woodland, agriculture, and fallow. At 25 sites, soil samples were collected in 4 1m2 pits (depth of 150cm) at 6 depth intervals. Soil carbon (SOC) levels varied considerably in the top 10cm even within the same land use type. Surface carbon levels in Miombo soils varied from 1.2%-3.7%. Agricultural soil carbon was depressed with surface layers ranging from 0.35-1.2% carbon. Due to land pressures 'fallow' areas are also used for grazing and firewood collection and this use has kept SOC levels degraded at most sites, (surface soils 0.65-2.3% C). On average, agricultural soils contain 40% less soil carbon than the natural miombo woodlands.

Mapping land cover and land use change in Zimbabwe
D. Kwesha and J. Mambo
Abstract
In 1996 mapping of land cover in Zimbabwe was completed using 1992 Landsat TM Imagery. The results show that more than 60% of the country is under some form of woody vegetation cover. The distribution of the woody cover varies from one land tenure to another. Most of the vegetation cover is in large-scale commercial farming areas and protected areas such as gazetted forest areas and national Parks. This baseline information is useful for monitoring change in the forest resources and enhancing their sustainable management. An attempt is now being made to assess changes in land cover/ land use using multi-temporal satellite data, aerial photographs and GIS at local level. This is being done in different land tenure categories namely, Forest Land, Communal Lands and Resettlement Areas. Preliminary results show an average deforestation rate of between 0.5 to 5 % per annum in the different land tenure classes.

Climatic and synoptic controls for haze layers along the eastern coastal region of southern Africa
D. C. Stein, R. J. Swap, S. J. Piketh, T. Elias, B. G. Doddridge and R. T. Bruintjes
Abstract
As part of the August-September SAFARI 2000 dry-season campaign, two SAWS 690A Aerocommander research aircraft were used to collect atmospheric chemical and meteorological data. During coastal flight missions along the eastern coastline of southern Africa, single and multi-layer haze features were observed. Vertical profiles from four

coastal flight missions including measurements of O_3, CO, and aerosol concentrations, are utilized from the characterization of these haze layer structures. The profiles that extend from the marine boundary layer to approximately 3500m, capture as many as three different regions of flow. To further understand these stratified flow regimes, back trajectories were calculated for three vertical levels (750m, 1500m, and 2500m) for several eastern coastal locations. The trajectory and profile data were analyzed in conjunction with synoptic data to evaluate a hypothesis put forth by Garstang et al, (1996) which stated that the distribution of optically impacted air masses would be different from year to year based on overall climatic conditions. A comparison of SAFARI-92 data collected during the El Nino influenced 'dry' year of 1992 and data collected during the La Nina influenced 'wet' year of 2000 provide the unique opportunity to test the Garstang hypothesis. Synoptic data illustrate that the large-scale circulation patterns for the dry-season periods corresponding to these field campaigns were significantly different from one another. The most important differences regarding trace gas and aerosol distribution as follows: 1) during SAFARI 2000, col regions served as accumulating mechanisms rather than subcontinental anti-cyclonic gyres that were predominant in SAFARI-92; 2) a greater frequency of westerly waves passage in 2000 prevented the extent of 'air-mass' build up seen during SAFARI-92 and shaped trace gas and aerosol transport to the Indian Ocean.

Variability in tropical tropospheric ozone from the 1998-2000 SHADOZ (Southern Hemisphere ADditional OZonesondes) data

J. C. Witte, A. M. Thompson, F. J. Schmidlin, S. J. Oltmans and G. J. R. Coetzee

Abstract

The first view of lower stratospheric and upper tropospheric structure from sondes is provided by a 3-year, 10-site record from the Southern Hemisphere Additional OZonesondes (SHADOZ) network: http://code916.gsfc.nasa.gov/Data_services/shadoz. Observations covering 1998-2000 were made over Ascension Island; Nairobi, Kenya; Irene, South Africa; R,union Island; Watukosek, Java; Fiji; Tahiti; American Samoa; San Crist¢bal, Galapagos; Natal, Brazil. A zonal wave-one pattern (referring to ozone mixing ratios greater over the Atlantic and adjacent continents than over the Pacific and eastern Indian Ocean), persists all year. The wave, predominantly in the troposphere and with variable magnitude, appears to be due to general circulation - with subsidence over the Atlantic and frequent deep convection over the Pacific and Indian Ocean. The variability of deep convection - most prominent at Java, Fiji, Samoa and Natal - is explored in time-vs-altitude ozone curtains. Stratospheric incursions into the troposphere are most prominent in soundings at Irene and Reunion Island. Analyses related to ozonesonde accuracy precision, accuracy and satellite evaluation are also presented. Specifically, the following types of uncertainties and accuracies within the SHADOZ ozone data set are evaluated: (1) imprecisions in stratospheric ozone profiles and in methods of extrapolating ozone above balloon burst; (2) comparisons of column-integrated total ozone from sondes with total ozone from the Earth-Probe/TOMS (Total Ozone Mapping Spectrometer) satellite and ground-based instruments; (3) possible biases from station-to-station due to variations in ozonesonde characteristics. The key results are: (1) Ozonesonde precision is 5%; (2) Integrated total ozone column amounts from the sondes are in good agreement (2-10%) with independent measurements from ground-based instruments at five SHADOZ sites and with overpass measurements from the TOMS satellite (version 7 data). (3) Systematic variations in TOMS-sonde offsets and in ground-based-sonde offsets from station to station reflect biases in sonde technique as well as in satellite retrieval. Discrepancies are present in both stratospheric and tropospheric ozone. Ozone profile measurements from the SHADOZ stations are evaluated with respect to: (1) variability (layer averages of ozone mixing ratio); (2) comparisons with standard profiles used in satellite retrievals. In the latter case there is considerable variation among SHADOZ stations. In the lower troposphere, the amount of underestimate or overestimate of ozone in the satellite algorithm is calculated on the basis of the SHADOZ data. The data from Lusaka launches during SAFARI-2000 are a large contrast from the climatological pattern used in TOMS retrievals.

Recommended trace gas emission factors for the production and use of biofuels

R. J. Yokelson, I. T. Bertschi, T. J. Christian, D. E. Ward and W. M. Hao

Abstract

Approximately one-half of the world's population uses biomass fuels (biofuels) for cooking, heating, and lighting. This accounts for the second largest portion of global biomass burning. In sub-Saharan Africa, 90-98% of residential energy is from biomass with ~90% of that energy provided by fuel wood consumption (usually in open fires) and ~10% from charcoal burning (usually in simple stoves). Previous studies of the emissions from the production and use of biofuels in the tropics measured only a few compounds. In September 2000, we used open-path FTIR (which provides an artifact-free overview of the trace gases present above several ppb) to quantify 18 of the most abundant trace gases emitted by wood and charcoal cooking fires and an earthen, charcoal-making kiln; all built by rural

inhabitants in Zambia. These are the first, in-situ measurements of an extensive suite of trace gases emitted by tropical biofuel burning. We report emission ratios and emission factors for (in order of abundance) carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), acetic acid (CH_3COOH), methanol (CH_3OH), formaldehyde (HCHO), ethene (C_2H_4), ammonia (NH_3), acetylene (C_2H_2), nitric oxide (NO), ethane (C_2H_6), phenol (C_6H_5OH), propene (C_3H_6), formic acid (HCOOH), nitrogen dioxide (NO_2), hydroxyacetaldehyde ($HOCH_2CHO$), and furan (C_4H_4O). Compared to previous work, our emissions of organic acids and ammonia are 3-6.5 times larger. Another significant finding is that reactive oxygenated organic compounds account for 70-80% of the total nonmethane organic compounds. For most compounds, the emissions from the combination of making and burning charcoal are 3-10 times larger than the emissions from wood fires; per unit mass of fuel burned. The charcoal cycle releases about double the emissions that wood burning releases per unit energy provided. The potential value of energy plantations (near cities) or high-yield kilns is noted. We estimate that Zambian savanna fires produce more annual CO_2, formic acid, and NO_x, than Zambian biofuel use by factors of 2.5, 1.7, and 5, respectively. However, biofuels contribute larger annual emissions of methane, methanol, acetylene, acetic acid, formaldehyde, and ammonia by factors of 5.1, 3.9, 2.7, 2.4, 2.2, and 2.0, respectively. Annual CO and C_2H_4 emissions are approximately equal from both sources. Coupling our data with recent estimates of global biofuel consumption implies that global biomass burning emissions for several compounds are much larger than previously reported. Biofuel emissions are produced year-round, their initial atmospheric processing is different than for savanna fire emissions, but they could strongly impact the tropical troposphere.

The role of heterogeneous processes in modifying the chemical composition of wet deposition in a semi-arid area of South Africa

J. N. Mphepya, J. J. Pienaar, C. Galy-Lacaux and V. Pont

Abstract

The major power generation activity in South African is coal-based and located on the Mpumalanga highveld close to the South African coalfields. This relatively small industrialized region is responsible for 86% of all particulate, 94% of all SO_2, and 91% of all NOx emissions in South Africa. The dispersion of these relatively high regional emissions is hampered by a frequently occurring anticyclonic circulation situation. This unfavorable dispersion climatology, combined with relative high emissions of sulphur and nitrogen from the region, highlights the importance to study air pollution on a regional scale in order to assess potential impacts. The results presented here form part of the IDAF (**I**GAC **D**EBITES **AF**RICA) program, as well as the SAFARI'2000 project. Experimental data on aerosol chemical composition and gaseous concentrations from semi-arid savanna site, Amersfoort is presented for 2001. The analytical results indicate three strong signatures: marine, terrigenous and anthropogenic sources. The anthropogenic signature is dominant and related to fossil fuel combustion, confirmed by a high sulphur content in precipitation (59.1 $\mu eq.L^{-1}$), in aerosols (3.8 $\mu eq.L^{-1}$) and in gas phase (6.3 ppb). A statistical analysis of the aerosol chemical composition clearly indicates that SO_4^{2-} is strongly correlated with NH_4^+, and terrigenous ions, i.e., Ca^{2+} and Mg^{2+}. A similar relationship was observed between all the terrigenous ions, NH_4^+ and SO_4^{2-} in the precipitation composition. To further understand the wet deposition data, the interactions between gas and particles were investigated by using a gas aerosol equilibrium model (SCAPE, Simulating Composition of Atmospheric Particles at Equilibrium). The model accurately represents the mean aerosol composition for Amersfoort. It was also found that heterogeneous processes involving sulphate and terrigenous compounds are important and play a major role in partitioning semi volatile species, such as ammonia, between the gas and aerosol phases.

Bare ground and bovines: Effects of grazing history and intensity on savanna soils and vegetation

C. J. W. Feral and H. E. Epstein

Abstract

Cattle grazing is broadly associated with both vegetation changes, in particular bush encroachment, and soil nutrient changes in savannas worldwide. The removal of grasses, with a subsequent opening of gaps for competing species, and associated shifts in nutrient availability are frequently cited as key factors in plant community changes that result from cattle grazing. We studied the effects of continual and discontinued cattle grazing on the proportion of bare ground and the vegetation composition along grazing intensity gradients. We chose two locations with nearly opposite grazing histories near Ghanzi, Botswana; a cattle farm that had been ungrazed, except by wildlife, until 1994 and a former cattle farm that has supported only wildlife since 1995. At each farm, we established 10m X 10m plots at increasing distances (up to 3km) along two radii that extended from a central borehole (watering point), producing grazing intensity gradients with decreasing distance to the boreholes. Bare ground and vegetation composition were measured along three 10-meter lines in each plot Proportional cover of bare ground decreases logarithmically ($r^2 = 0.77$) with distance from borehole at the currently grazed site, however, there is no relationship

between distance and bare ground cover at the site no longer grazed by cattle ($p>0.05$). Grass density increased with distance (up to 1.5 km) from the borehole at both sites ($r^2=0.69$-0.86). Forb density decreased with distance at the site without cattle ($r^2=0.48$). The results suggest that grazing intensity has a dominant control on the proportion of bare ground and grass cover, and that recovery from cattle grazing may be initially dominated by forbs and not by grasses or shrubs.

Validation of the MODIS active fire product over southern Africa with ASTER data
J. T. Morisette, L. Giglio, I. Csiszar and C. O. Justice

Characterization of southern African aerosols through compound specific isotope analysis and trajectory study
K. A. Billmark, R. J. Swap and S. A. Macko

Abstract

Intense seasonal biomass burning in southern Africa emits copious trace gas and particulate organic aerosols that accumulate and recirculate within a well-defined synoptic system that persists over the region for long periods of time. Biomass burning emissions participate in chemical reactions within the atmosphere, decrease incident solar radiation to the Earth's surface and negatively impact visibility through the creation of a regional haze layer. To better study these impacts of organic aerosols, specific knowledge regarding the composition and transport of the aerosol loading must be understood. The Southern African Regional Science Initiative (SAFARI 2000) was conducted in part to investigate the impacts of increasingly anthropogenic emissions on southern African biogeochemical cycling. This study explores the understanding of regional atmospheric transport through the identification of chemical biomarkers to describe aerosols collected during the SAFARI 2000 dry season research campaign. Total suspended particulate aerosol samples were collected diurnally for a period of two weeks in Mongu, Zambia. The area surrounding Mongu is characterized by high biomass burning emissions of river floodplain grasses and woodland savanna during the dry season. Fatty acids were extracted from the collected aerosols and analyzed for their carbon isotope compositions. These results were compared to both synoptic meteorological patterns over the region as well as to modeled air parcel trajectories to better understand compositional and isotopic differences resulting from possible directional vegetation shifts. Compound-specific isotope analysis revealed that the lower molecular weight fatty acids (C12 – C19) exhibited less negative $\delta^{13}C$ values than the higher molecular weight fatty acids (C20 – C34). This trend reflects the contribution of C_4 metabolizing grasses to organic aerosol loads through biomass combustion. Both high and low molecular weight fatty acids experienced temporal variations in $\delta^{13}C$ coincident with modeled air parcel trajectories.

Evaluation of the MODIS BRDF/Albedo products over Zambia using aircraft and tower-based measurements
J. L. Privette, M. Mukelabai, C. Gatebe and C. Schaaf

Abstract

The MODIS albedo product (MOD43) provides a much more spatially and temporally dynamic boundary condition for various large-scale process models than was previously available. This variability, however, suggests that validation must occur at many sites and over long time periods. Simultaneously with the start of the Terra MODIS data stream, we commenced tower-based albedo measurements over a 12 m high Kalahari woodland at the EOS Land Validation Core Site at Mongu, Zambia. Broadband and Photosynthetically-Active Radiation (PAR) albedo were collected each 15 minutes, and continue to the present. The aircraft-based Cloud and Atmospheric Radiation (CAR) sensor, flown on the Univ. of Washington's CV580 aircraft, also sampled this site during the SAFARI 2000 Dry Season Campaign in September 2000. Using data from these sources, we evaluate the uncertainty in the MODIS albedo product as a function day-of-year and leaf area index, also collected throughout this period. The uncertainty is characterized for the Terra-only and the Terra plus Aqua data sets.

Transport and diffusion in southern African anticyclonic gyre circulation
W. Zhakata, S. J. Piketh, G. D. Djolov and H. J. Annegarn

Abstract

The atmospheric gyre may be considered to be a stable anticyclonic environment that inhibits vertical exchanges in the atmospheric column, stratifying the troposphere into persistent layers in which residence times of pollutants are prolonged over days to tens of days. Under these conditions and over a considerable period of time, air in a given volume may return to its original point of origin or complete more than one cycle of recirculation. This results in the transport of trace gases and aerosols from their sources to other areas. Prior to the SAFARI 2000 project, it has not been possible to quantify the different sources, which contribute to the atmospheric gases fluxes due to lack of reliable emissions data. This study looks at the long-range pollutant transport, considering dominant large-scale

horizontal fields of motion as well as vertical motion. In so doing, it is assumed that some air pollutants are transported far beyond their points of release. The model, which is used for the study relies on numerical solution techniques. An existing and proven long-range air pollutants transport and diffusion model, developed for Europe, and modified for applications in Southern Hemisphere will be used, especially for answering relevant questions and problems connected to the SAFARI 2000 initiative. The model combines the positive features of the Lagrangian and Eulerian hydrodynamic approaches. It will be used to study the integrated role of the atmosphere in both the conditions of semi-closed anticyclonic circulation as well as non-gyre situations over the southern Africa region.

Mozambique Floods 2000 Impact On Biodiversity Of Limpopo River Basin

A. Sitoe, M. Ferrão, N. Ribeiro, R. Bandeira, T. Chiconela, L. Nhamucho and G. Albano

Abstract

Mozambique 2000 floods were the most devastating in the last 50 years and affected mainly the south of Mozambique (Gaza, Inhambane and Maputo Provinces). With the aim to contribute to an assessment of impacts of Limpopo floods on soils, water, people fauna and vegetation, a project was submitted to Ford Foundation and is being implemented by different teams of the Faculty of Agronomy and Forestry Engineering. The preliminary results refer to the evaluation of impacts on vegetation along the valley. During December 2001 we evaluated the diversity and biomass of the main vegetation types: grasslands, mangroves and coastal thicket, in Pafúri, Mabalane, Chokwé, Chibuto, Xai –Xai and Zongoene in Gaza Province. In grasslands plots of 900 m^2 were established and species cover assessed using Braun-Blanquet scale), green and dry weight (kg/ha) were evaluated. For mangrove and coastal thicket, transects of 100-150 m were established perpendicularly to the river and within them, plots of 20*50 m were used for species diversity and biomass evaluation. We did not find information related to the period before the floods in order to evaluate the impacts of floods 2000. Although taking some informal interviews with local people and authorities, no impacts in terms of specific diversity and quantity for grazing, are visible in the grasslands. Coastal thickets and mangroves in the Limpopo mouth (Zongoene and Xai-Xai) are the most affected vegetation types. Dry leaves and broken trees abound in coastal thicket and sand deposition (70 cm to 1m) is clear in the mangroves. As consequence, a considerable portion of mangroves (about 2.5 sq. Km) is now dead and the trees are under sand for more than half of their bole. Our conclusions are not final, as we need to evaluate other aspects such as soils, fauna and water, which are the results of the other components of the project. In general, the impacts of floods 2000 were evident only for the mangrove and coastal thicket. For mangroves we strongly recommend a continued evaluation of the forest recovery, and if needed, a plan of rehabilitation should be designed.

Tuesday October 8, 2002

Ecosystem and Land Processes

08:45 – 09:00
Overview of MISR SAFARI 2000 Validation/Calibration activities and some early results
M. C. Helmlinger
Abstract
In addition to continuous on-orbit acquisitions from the Terra platform during SAFARI2000, the MISR science team collected airborne data using AirMISR aboard the NASA ER-2 as well as ground truth data at two sites. Example aerosol and surface retrievals obtained using S2K data will be presented. A description of MISR data products, planned upgrades, and information on data access and visualization tools will be provided. A review of AirMISR and ground truth data taken during S2K will be followed by a discussion of possible research directions using these data.

09:00 – 09:15
Tree cover mapping in the Kalahari Transect using multi-resolution data sets
M. C. Hansen
Abstract
A multi-resolution approach to calibrating/validating tree cover in the Kalahari Transect is presented using field, IKONOS, ETM+ and MODIS data. The tree cover of an initial test area in Western Province Zambia is depicted and validated using field-measured tree cover data and ancillary maps. This map was used in testing various MODIS inputs, including level-1b data, monthly composites and annual metrics. The tests show that the composited data are only slightly less robust in terms of retaining spatial information as compared to the 1b data. A comparison of the validation test site is made with a subset of the initial global MODIS percent tree cover map. Results are favorable, save for a flat depiction of low-end tree cover (10-40 percent). This indicates either problems in the global training data set or signature limitations in this range of tree cover. Plans for mapping the Kalahari Transect include completing the Zambia test area, and adding like sites in the Democratic Republic of the Congo and in Botswana. For best results, a regional based data set using MODIS monthly composites as inputs is proposed.

09:15 – 09:30
Tree canopy effects on simulated water stress in southern African savannas
K. Caylor and H. H. Shugart
Abstract
A coupled energy and water balance model is used to simulate the effects of large tree canopies on soil moisture and water stress across a series of sites spanning a regional moisture gradient in southern Africa. The model tracks evapotranspiration from five components of the land surface at each site – the tree canopy, grass under and between tree canopies, and bare soil under and between tree canopies. The soil moisture dynamics are simulated at daily time steps and driven by a stochastic model of storm arrivals and storm depth. Evapotranspiration is modeled using the Priestly-Taylor approach, with potential evapotranspiration scaled by soil moisture availability. The soil moisture under tree canopies is compared to the soil moisture between tree canopies, and differences in average annual soil moisture stress conditions are analyzed at each site. The spatial distribution of large trees has important consequences on the small-scale soil moisture dynamics across the rainfall gradient. The results indicate that tree canopies serve to reduce soil moisture stress in the middle of the rainfall gradient. At the dry end of the rainfall gradient, the effect of tree canopies on soil moisture is dependent on the amount of yearly rainfall received.

09:30 – 09:45
Directional effects on observations of land surface temperature with AVHRR over Africa
A.C. Pinheiro, J.L. Privette, R. Mahoney and C.J. Tucker
Abstract
We characterized the directional effects on the thermal infrared signal retrieved by the NOAA Advanced Very High Resolution Radiometer (AVHRR). For that purpose, day and night GAC data were processed using the full swath width of the AVHRR/2. We developed a methodology for normalizing the land surface temperature to nadir observation and tested it over continental Africa. The methodology is based on ancillary structural information of the surface as well as empirical and modeled relationships between the scene endmembers. To assess the effectiveness of our method, we apply it to one of the EOS and SAFARI 2000 core sites: Skukuza, South Africa.

The directional trends of AVHRR estimates and modeled predictions are consistent and suggest that this approach could be further developed to help reduce the systematic bias in land surface temperature from AVHRR. Our method is general and applicable to other wide field of view sensors such as MODIS.

09:45 – 10:00

An overview of the SAFARI 2000 investigations of biogenic volatile organic carbon emissions

L. Otter, A.Guenther, J. Greenberg, P. Harley, C. Wiedinmyer, G. Fleming,, S. Owen, A. James, N. Hewitt, and E. Veenendaal

Abstract

Biogenic VOCs are important because of the impacts they have on atmospheric chemistry. VOC oxidation influences OH and ozone concentrations, and leads to the formation of CO, PAN and secondary organic aerosols. Tropical and subtropical regions, with their high temperatures and solar radiation, are the largest contributors to the global VOC budget. The Southern African Regional Science Initiative (SAFARI 2000) provided us with an opportunity to study VOC emissions in tropical and subtropical Africa. Emissions were measured at the leaf level at various sites including sites along the Kalahari transect, and Skukuza in the Kruger National Park (RSA). Detailed data on the plant physiology and the emissions from the species *Colophospermum mopane*, collected at the Maun site in Botswana, indicated that this species displays very high light dependent monoterpene emissions. At the Maun (Botswana) and Skukuza (RSA) sites canopy fluxes were measured using relaxed eddy accumulation techniques. The coupling of VOC data with CO_2/H_2O data at the Maun site provides us with information on the percentage of carbon lost from the ecosystem relative to the amount taken up. In addition to improved emission factor estimates, SAFARI 2000 efforts included the compilation of improved species distribution maps and LAI data. All this data has been combined and incorporated into a regional model to form spatial maps of VOC emissions across southern Africa. The results of the leaf and canopy level data, as well as the process of coupling emissions data, species data and satellite data to produce spatial maps of VOC emissions, will be discussed.

10:00 – 10:15

Nitrogen isotopic signatures of soils and plants along land-use gradients in the Kalahari,

J. N. Aranibar, S. A. Macko, I. C. Anderson, J. Ramotsho, H. H. Shugart

Abstract

Regional patterns of $\delta^{15}N$ (natural abundance of ^{15}N) around the globe indicate ^{15}N enrichment with aridity for soils, plants, animals and anthropological remains. Mechanisms of the nitrogen cycle in the soil-plant system, such as N losses relative to turnover, have been proposed to explain this pattern. However, changing patterns of disturbances with precipitation have been suggested to confound the effects of precipitation on the N cycle. In this study, nitrogen isotopic signatures of soils and plants are analyzed along disturbance gradients located in a precipitation gradient in the Kalahari sands. Nutrient stocks, gross mineralization and gross nitrification rates were also analyzed to assist with the interpretations of $\delta^{15}N$. In the more humid site, Mongu, cultivation and subsequent land abandonment increased soil $\delta^{15}N$, but not foliar $\delta^{15}N$. A higher plant utilization of nitrate in the disturbed site, produced by the higher nitrification rates observed, would explain this pattern. In the land-use gradients with intermediate mean annual precipitation, Maun and Okwa, overgrazing increased $\delta^{15}N$ values of both, soils and plants. Possible mechanisms of this ^{15}N enrichment are higher losses of gaseous N and export of plant material from the system caused by overgrazing. Although nutrient stocks were not always lower in overgrazed areas because of the confounding effects of export, transport and deposition of nutrients by cattle, the isotopic data indicated net N losses over the whole grazing areas. The most arid site, Tshane, showed an opposite response to overgrazing, presenting lower $\delta^{15}N$ values of soils and plants in the most disturbed site. Changes on the extension of the grass layer caused by high precipitation and overgrazing may have played a role on the isotopic signatures. This study shows that disturbances can increase soil and plant $\delta^{15}N$ by 3 ‰, affecting regional isotopic patterns. However, the response to disturbances was not consistent for soils and plants along the precipitation gradient, indicating that other processes in addition to N losses caused by plant consumption and export from the system act on N isotopic signatures.

10:15 – 10:30

On the Temporal Dynamics of Coupled Water and Carbon Exchange in an African Savanna: Implications for Predictions over Meteorological and Climate Time Scales

John D. Albertson, Christopher A. Williams, Todd M. Scanlon

Abstract

There is considerable uncertainty surrounding the role of savannas in global carbon and water cycles. There is also uncertainty regarding how change and variation in the climate system may induce disturbances or unrecoverable

change in the savannas, with direct consequences to the health of animal and human populations that depend on these landscapes. Short term water and carbon exchanges between these landscapes and the atmosphere are strongly coupled through the stomatal function of grass and trees. We report functional differences between these plant functional types derived from our recent 30-day field campaign conducted in southern Africa near Ghanzi, Botswana along the Kalahari Transect. This site is well suited for this purpose, with significant contrasts in grass and tree cover fractions over short spatial distances. We characterized the functional response of tree/grass/bare soil mosaics during a prolonged drydown following a large rain event (85 mm) at the end of the 2002 wet season, with a pair of tower sites: one dominated by woody vegetation (Acacia and Terminalia) and the other composed of native grasses, shrubs, and bare soil. These high-frequency exchange rates are ultimately modulated by the lower-frequency variability in the vegetation cover, as it responds to changes in forcing, such as water availability, across a range of time scales. We use remotely sensed data to characterize the interannual variability in vegetation cover in response to interannual changes in rainfall. In closing, we highlight the implications of the interplay between functional dynamics and structural dynamics, with a focus on water and carbon exchange in a semi-arid context.

10:45 – 11:00

Mapping of Ecological Change along the Okavango Delta, implications for water loss?

S. Ringrose, A. Jellema, P. Wolski, W. Timmermans, T. Meyer and E. Kabikwa

Abstract

Ecological mapping in the Okavango Delta and immediate drylands has resulted in the identification of 45 ecological areas, most of which pertain to specific Delta palaeo-environments. Mapping took place using Landsat TM imagery from the SAFARI2000 project. This Delta is normally divided into the Panhandle, Permanent Swamps, Seasonal Floodplains, Intermittently Flooded Floodplains and Drylands. A major purpose of this mapping exercise however was intended to obtain additional information in terms of ecological change along Delta drying gradients and to obtain preliminary data on present day water losses from Delta ecosystems. Existing work is mainly based on gross inflow and outflow data, the rationale here being the need for better data on which to base management decisions. Mapping and field verification took place partly though the use of high resolution video photography and IKONOS imagery in addition to field work data. Ecological changes along the drying gradients varies from the proportion of islands to the different nature of island/riparian zone vegetation. Also the extent and nature of the riparian zones change in a downstream direction. Further analysis showed that only a few of the 45 ecological areas were either wet or in direct contact with water during the time of satellite overpass. These include: Open shrubbed woodlands on islands, Tall dense grassland on inundated higher floodplains, Dense grassland on inundated lower floodplains, Seasonal swamp and floodplain edges, Permanent backswamp areas, Tall channel fringing emergents, channels and recently inundated floodplains and Riparian zones. While the results of this work indicate where further high resolution imagery is needed some preliminary indications in terms of evapotranspiration relationships are presented.

11:00 – 11:15

Assessment of the Vegetational Response to Flooding in the Okavango Delta, Botswana using Landsat and EO-1 Remotely Sensed Data

A. Neuenschwander, M. M. Crawford and S. Ringrose

Abstract

A sequence of remotely sensed data was acquired by the Landsat 7 and NASA Earth Observing-1 (EO-1) satellites that highlighted the annual flooding of the lower Okavango River. The extent and inaccessibility of many areas of the Delta make the application of remote sensing technology extremely attractive, if it can be shown to effectively map important land cover and geomorphological characteristics (or their surrogates). Only limited work has focused on characterizing the complex spatial and temporal patterns of vegetation response within the Delta via remote sensing, partially due to availability of a multitemporal sequence of data with adequate spatial and spectral resolution. While results of previous AVHRR and Landsat Thematic Mapper based investigations were promising, the increased dynamic range, improved signal to noise ratio, additional multispectral bands, and higher spatial resolution panchromatic band of the Advanced Land Imager (ALI) instrument on EO-1 potentially provide greater capability for characterizing the ecology of the Delta and mapping flood events. This includes mapping and characterizing the response of floodplain vegetation before, during, and subsequent to inundation and tracking the progression of the flood toward the distal regions of the Delta. Because flooding occurs during the winter dry season (June through August) when much of the vegetation is essentially dormant, so vegetation response is essentially in the form of regeneration. Increased discrimination of vegetation response may also be possible using the EO-1 hyperspectral sensor, Hyperion. Initial analysis of the ALI data via supervised classification clearly showed macro flood features (such as the filling of pools

in advance of the main flood front), delineation of downstream channel flow areas, and lateral-downstream inundation of the floodplain. These patterns and the proportions of pool flooding, channel flooding and floodplain flooding (impoundment) varied distally from the wetter seasonal swamps through the drier seasonal and occasional swamps. Historical evidence suggesting that while the flood helps to regenerate macrophytes and grasses contained within the floodplain boundaries, lateral groundwater seepage has little or no obvious effect on the peripheral riparian tree cover was supported by the EO-1/Landsat based analysis. Full riparian zone vegetation response does not occur until November due to seasonal warming, day lengthening and seasonal rains. Hence, based on flood impact, more of the evapotranspiration loss than anticipated seems to occur (over 6-9 months) within the floodplain vegetation, while much of the riparian zone loss is restricted to water resulting from groundwater seepage circumscribed by summer events which include renewed rainfall. A limited comparative study of Landsat ETM+, ALI, and Hyperion via classification indicated that increased discrimination can often achieved by ALI relative to Landsat ETM+ and that the additional bands of Hyperion both provide increased capability for atmospheric correction and in some cases, improved characterization of vegetation signatures.

11:15 – 11:30

Influencing policy decisions through remote sensing : South African ISRDS and Umlindi approaches

B. M. Petja, H. J. Annegarn, T. S. Newby and T. A. Saidi

Abstract

The government of South Africa has identified areas prioritized for rural development referred to as development nodes. The node is a focal area identified for the implementation of the Integrated Rural Development falling under the government's Integrated Sustainable Rural Development Programme (ISRDP). They provide a basis for geographic targeting of resources. The aim of the ISRDP programme is to conduct a sustained campaign against rural and urban poverty including a focus on underdevelopment. This will result in coordinated deployment of resources to target these spheres. The concept of nodal development is based on spatial targeting, where resources are directed to selected areas in response to identified development problems and opportunities (IDT, 2000). A remote sensing approach integrated with field data has been adopted for providing solutions for sustainable natural resource management. The major focal areas include aspects of land degradation, alien invader vegetation, erosion risk, vegetation condition and land use. The expected outcomes will include satellite image products verified and calibrated with field data which will serve as guidelines and reference for sustainable natural resource management and land use planning thereby positively influencing rural development. Data coming out of SAFARI 2000 is currently being experimented on the nodes for biomass production, grazing capacity and land cover. This include specifically MODIS and ASTER data. The Umlindi information system integrates satellite and climate data for early warning and decision support on drought and agricultural production.

Mozambique Floods 2000 Impact On Biodiversity Of Limpopo River Basin

A. Sitoe, M. Ferrão, N. Ribeiro, R. Bandeira, T. Chiconela, L. Nhamucho and G. Albano

Abstract

Mozambique 2000 floods were the most devastating in the last 50 years and affected mainly the south of Mozambique (Gaza, Inhambane and Maputo Provinces). With the aim to contribute to an assessment of impacts of Limpopo floods on soils, water, people fauna and vegetation, a project was submitted to Ford Foundation and is being implemented by different teams of the Faculty of Agronomy and Forestry Engineering. The preliminary results refer to the evaluation of impacts on vegetation along the valley. During December 2001 we evaluated the diversity and biomass of the main vegetation types: grasslands, mangroves and coastal thicket, in Pafúri, Mabalane, Chokwé, Chibuto, Xai –Xai and Zongoene in Gaza Province. In grasslands plots of 900 m^2 were established and species cover assessed using Braun-Blanquet scale), green and dry weight (kg/ha) were evaluated. For mangrove and coastal thicket, transects of 100-150 m were established perpendicularly to the river and within them, plots of 20*50 m were used for species diversity and biomass evaluation. We did not find information related to the period before the floods in order to evaluate the impacts of floods 2000. Although taking some informal interviews with local people and authorities, no impacts in terms of specific diversity and quantity for grazing, are visible in the grasslands. Coastal thickets and mangroves in the Limpopo mouth (Zongoene and Xai-Xai) are the most affected vegetation types. Dry leaves and broken trees abound in coastal thicket and sand deposition (70 cm to 1m) is clear in the mangroves. As consequence, a considerable portion of mangroves (about 2.5 sq. Km) is now dead and the trees are under sand for more than half of their bole. Our conclusions are not final, as we need to evaluate other aspects such as soils, fauna and water, which are the results of the other components of the project. In general, the impacts of floods 2000 were evident only for the mangrove and coastal thicket. For mangroves we strongly recommend a continued evaluation of the forest recovery, and if needed, a plan of rehabilitation should be designed.

11:30 – 11:45

The Use Of Remote Sensing To Evaluate Environmental Impacts Of Mining In The Central Rand

N. F. Mphephu, H. J. Annegarn and M. J. Viljoen

Abstract

Gold mining activity on the Central Rand has left a legacy of environmental problems. The major impacts are on air (dust pollution), surface and ground water (dissolved salts) and the sterilization of land for development. These impacts are mainly associated with the establishment of numerous tailings dams during mining operations. To date approximately 240 tailings dams covering an area of 44 000 hectares, are registered in the Witwatersrand goldfield of which 70 are in the Central Rand. Currently most of these tailings dams are being reprocessed for trace amounts of gold (± 0.5 g/t) and this has opened land for development. However there are tailings dams which are still causing problems to the community and environment. The use of MAS and ASTER imagery and aerial photographs provide a method of monitoring changes taking place in the area. They provide a tool to classify existing tailings dams into rehabilitated, unrehabilitated, active tailings dams, partly reprocessed and fully reprocessed tailings dams. The imagery also enables the detection of vegetative cover and surface land use, as well as iron precipitation, polluted water and spillages.

11:45 – 12:00

Derivation of the effective value of the surface albedo for improving the estimation of the aerosol radiative forcing from ground-based remote sensing.

T. Elias

Abstract

Ground-based sun/sky radiometers allow to retrieve aerosol properties with a good precision because the surface contribution is reduced by a further back-scattering of upwelling reflected radiation. However surface reflection can still contribute to the downwelling radiance up to 30% (for a surface albedo of 0.4) at scattering angles in the range 100-120°, angular interval generally used for inferring the real part of the refractive index and the shape of the particles. One difficulty in determining the surface albedo is that the surfaces are rarely spatially homogeneous. Consequently an effective value of the surface albedo has to be defined. The effective value depends on the optical thickness (therefore on the wavelength and on the aerosol load), and also depends on the instrument viewing optics and geometry. A method is proposed for deriving the effective surface albedo $\rho Surf(\lambda)$ when measuring with a sun/sky-photometer. The dependence of measured radiance $L(\theta Sun, \theta V)$ on solar zenith angle θSun (θV is the viewing zenith angle in the solar principal plane) is correlated to radiative transfer calculations for different values of $\rho Surf(\lambda)$ (the surface albedo is assumed to be independent on the solar zenith angle). For decreasing the sensitivity of the method to the aerosol optical thickness $\delta aer(\lambda)$ and to the single scattering albedo, the ratio

$$\frac{L\,\theta Sun, \theta V=40°}{L\,\theta Sun, \theta V=70°}$$

is studied, which allows to also cancel the calibration uncertainty. The sensitivity study for $\delta aer(\lambda=870\ nm)=0.04$ shows that $\rho Surf(\lambda=870\ nm)$ could be derived with a precision of 10%. 15 case studies are selected for Pietersburg's site of AERONET during SAFARI 2000. The results show a strong effect of the spatial heterogeneity: $\rho Surf(\lambda=870\ nm)=0.2\pm0.03$ when the instrument points towards the South-West (the morning) and $\rho Surf(\lambda=870\ nm) = 0.36\pm0.05$ to the South-East (the afternoon).

Afternoon Session: Fuel, Fires and Emissions

14:00 – 14:15

Mapping of southern Africa biomass burning - the regional Moderate Resolution Imaging Spectroradiometer (MODIS) burned area product, validation results, product intercomparison and sensitivity analysis

D. P. Roy, S. Korontzi, C. O. Justice, T. Landmann, J. Le Roux, S. Makungwa, K. Dunham, R. Dutoit, K. Gumbo, A. Zacarias, P. Mushove, P. Dube, B. Tacheba, P. Frost, J. Morisette, D. Davies

Abstract

The SAFARI 2000 dry season campaign included a number of biomass burning experiments with new generation satellite data providing a mechanism to scale up these experiments to regional scale. The MODerate resolution Imaging Spectroradiometer (MODIS) was launched December 1999 on NASA's TERRA satellite, and started to provide quality daily observations over southern Africa towards the end of the 2000 dry season. A regional MODIS burned area product that depicts the 500m location and approximate day of burning for the end of 2000, during the dry season campaign, and for all the 2001 fire season in southern Africa is presented. The potential research,

application, and policy usages of satellite derived burned area data put a high priority on providing statements concerning their accuracy. Comparison of the 2000 MODIS burned area product with a regional 1km product produced by the European Commission (GBA 2000) and the impact of the substantial differences observed between these products in the context of a regional emissions model are illustrated. MODIS validation results produced by comparison with burned area maps derived from Landsat ETM+ time series data by members of the Southern Africa Fire Network (SAFNet) are presented. Field and satellite observations of prescribed fires in different South African savanna types and the results of a simple reflectance model parameterized for the combustion completeness and the fraction of the remotely sensed observation that burned are used to illustrate fundamental mapping and validation sensitivity issues. Implications for development of methods to retrieve the combustion completeness and the proportion of the pixel that burned, and to map the spatial extent of burned areas with known detection capabilities in these respects, using multi-temporal reflective wavelength data, are described.

14:15 – 14:30

Biomass burning parameters of four experimental fires in the Western Province, Zambia

J. M. C. Pereira, A. C. L. Sa, J. M. N. Silva, D. E. Ward and N. Ribeiro

Abstract

Four experimental burns were carried out in the Western province of Zambia, during the SAFARI 2000 Third Intensive Field Campaign, three in dambo grasslands, and one in a miombo woodland. Fire behavior was characterized at the three dambo fires, and combustion completeness and biomass burnt were calculated for all the fires. Fireline intensity ranged from 4238 $kW.m^{-1}$ to 10250 $kW.m^{-1}$. Combustion completeness of grass fuels varied from 0.81 to 0.89, and was lower for live fuels and coarser fuels in the woodland. Fuel consumption in the dambo burns ranged from 0.362 to 0.479 $kg.m^{-2}$ and was lower (0.176 $kg.m^{-2}$) at the woodland site. The biomass burning parameters measured fall within the range of values published for similar ecosystems in the region. The most intense fire had the highest fireline intensity value reported for grass fires in the region, and one of the higher observed in southern Africa. Two of the burns were performed simultaneously with overpasses from the Terra satellite, and from the NASA ER-2 research airplane, carrying an image spectrometer. The chemical composition of smoke plumes from two of the burns was sampled by an aircraft to measure emission factors, which can be coupled with our measurements of fuel consumption to allow regional emissions estimates.

14:30 – 14:45

Recommended Trace Gas Emission Factors For African Savanna Fires and Post-Emission Transformations

R. J. Yokelson, I. T. Bertschi, T. J. Christian, P. V. Hobbs, D. E. Ward and W. M. Hao

Abstract

An airborne FTIR (AFTIR) was installed on the UW Convair-580 in August/September 2000 and quantified 12 of the 15 major trace gases in minutes-old smoke from 10 fires in arid and humid savannas. In order of abundance they were: CO_2, CO, CH_4, NO+NO_2, C_2H_4, CH_3COOH, CH_2O, CH_3OH, HCN, HCOOH, NH_3, and C_2H_2. The FTIR measurements in nascent smoke yield true initial emission factors (EF) for reactive species such as oxygenated volatile organic compounds (OVOC), which accounted for 60% of the non-methane organics. We obtained an EFHCN (a biomass burning tracer) that was 20 times higher than a previous report. Algorithms for predicting the trace gas emissions from a range of naturally-occurring savanna fires are presented and examined in a global context. In a separate ground-based field experiment, smoke from residual smoldering combustion, which cannot be sampled from the air, was shown to be of importance in emissions estimates. In February/March 2001 we carefully simulated savanna fires in our lab where we could capture all the smoke, ensure the smoke was well-mixed, and probe higher concentrations than in an aircraft. We measured the emissions with AFTIR and open-path FTIR, a proton-transfer mass spectrometer from the Max-Planck Institute of Chemistry (MPI), canister sampling by MPI, UC Irvine and the Forest Service, and filter sampling by the Forest Service and Lawrence Berkeley Laboratory. This was the most comprehensive characterization of fire emissions to date. The lab results were carefully meshed with the field results to expand the set of recommended savanna fire emission factors. A proper initial description of smoke is crucial to model post-emission impacts in the atmosphere. For instance, new photochemical models that include OVOC show that they cause much higher HO_x and much faster O_3 production in downwind biomass burning plumes. AFTIR documented rapid post-emission chemical transformations consistent with the model predictions. The ratio of excess ozone to excess CO reached as high as 9% after < 1 hr of photochemical processing. The rapid disappearance of hydrocarbons indicated OH levels of ~ 1.7×10^7 cm^{-3}. Thus 10-20% of ozone production occurs at a scale that is sub-grid for global models and the NO_x lifetime is so short that the much-discussed "convection enhancement factor" is greatly reduced in importance. In addition, cloud processing of smoke significantly reduced CH_3OH, NH_3, NO_2, SO_2, and CH_3COOH while increasing NO and HCHO. Several mechanisms for these changes

are considered and the potential for clouds as a medium for heterogeneous chemistry and carbon-enrichment of aerosols is high. We also measured vertical profiles for CO_2, CO, CH_4, and H_2O in aged/dispersed smoke under TERRA/ER2 at 5 locations in the southern African gyre, once in the continental outflow over the Atlantic, and once in the inflow over the Indian Ocean and we observed trace gas enhancement in the free troposphere due to cumulus convection. The emissions from savanna fires (including residual smoldering) and the production and use of biofuels contribute substantially to the observed regional haze and global impacts. It is hoped that the burned area estimates, AERONET observations, regional meteorology, and our regional vertical profiles could be rationalized.

14:45 – 15:00
Summary of a Few Smoke Emissions Studies in Zambia
D. E. Ward

Abstract

Smoke emissions are a dominant source of aerosols and trace gases in the atmosphere over Zambia. Generally, fires producing smoke burn with progressively higher rates of heat release and of smoke production as the dry season progresses from June to October. To characterize trends in smoke production on a regional basis, a network of handheld sun photometers was operated in the western part of Zambia during the dry season campaign from June to the end of September 2000. More than 40 stations were located on an approximate 1 x 1-degree grid with observations taken by local people at 30-minute intervals from 08:00 ti 17:00 local time each day. The network was co-located with AERONET automatic sun photometers and cross-calibrated against the automatic sun photometers. During the Zambian International Biomass Burning Emissions Experiments (ZIBBEE) of 1997, aircraft were used to measure vertical profiles of aerosols from the surface to near the top of the mixing layer of the atmosphere (to about 3600 m). During the SARARI 2000 campaign, these calibrations were used to relate measured aerosol optical depth to the average concentration of aerosol in the atmosphere. Fires used in the chitemene agricultural system of the southern part of Africa were studied during a period of August to November of 1993. For this type of agricultural system, the limbs and tops of trees are lopped and hand carried to central garden spots. At the end of the dry season, fires are ignited in the piled material to develop an ash bed that is used for supplying nutrients to the soil. Crops are grown on the garden spots for 5 to 7 years and then the area is abandoned and changes into a fallow condition. Combustion factors and emissions from periodic fires burning across the fallowed areas as well as the active chitemene sites were sampled for combustion factors, fire behavior, emissions production and nutrient cycling. In Zambia, biomass accounts for 70 to 80% of the energy budget. Biomass energy is used as the primary source of heat for cooking and home heating. Charcoal is predominantly used in urban areas and urban households consume about 85% of the charcoal with industry using another 4% and rural households using 11%. The way in which kilns are constructed and tended determines to a large extent the completeness of the oxidation process and the emissions released from the kiln. This study conducted in Zambia during the dry season of 1994 and the wet season of 1995 found no statistical difference in emissions from dry Vs wet season kilns. Emission factors based on the amount of charcoal produced were 3057, 599, 88, and ll.7 g kg^{-1}. The efficiency of the earthen charcoal kilns in converting wood to charcoal ranged from 22.9% to 34.8%.

15:00 – 15:15
Improved regional fire emissions estimates from Kruger National Park (KNP) biofuels
T. Landmann and S. Korontzi

Abstract

The objective in this study is to couple field fuel and fire data from contemporary multi-sensor remote sensing with emission status data from experimental laboratory fires to derive an explicit spatial fuel and emissions model for the Kruger National Park (KNP) region. The use of new high resolution remote sensing fuel mapping techniques and daily fire characterization information from 250 meter resolution MODIS reduces the uncertainties in the extrapolation of field data to large regions in burnt areas and vegetation status mapping. Previous errors of uncertainties in spatial models that drive emission estimates are large (DeFries *et al*, 1999; Barbosa *et al*, 1999) and there is a need to assess fire emissions in the atmosphere (Eva & Lambin, 1998) and the knock-on effects of these on atmosphere/climate and physical land use changes. We found significant relationships between field measured woody fuels (t/ha), litter (t/ha), greenness of vegetation, grass mass (t/ha) and 30 meter resolution Landsat reflection. Fuel consumption rates from 250-meter resolution MODIS data was integrated into the fuel model. The emission factors are a function of the fuel type variability that is combustion efficiency. Resulting CO and CO_2 emissions (<2.5 µm) in 250-meter cells over the fuel sampling transect show lower emission estimates in dry grassland sites where the fuel is most senescent, than in the infertile woody savannas in the southern KNP. The model will be appended with combustion chamber measurements on emission factors of halogen-, nitrogen-, sulfur-, carbon-

containing compounds. The result is a regional scale emissions data set that can extend current fire and vegetation monitoring systems.

15:15 – 15:30
A dynamic emissions model for savannas
R. J. Scholes and T. Landmann

15:45 – 16:00
Emissions of Volatile and Particulate Compounds from Experimental Burns of Southern African Biofuels
W. C. Keene, J. M. Lobert, J. R. Maben, D. H. Scharffe, P. J. Crutzen, C. Brain, C. Hely, T. Landmann and D. Kayambazinthu

Abstract
As part of the SAFARI-2000 campaign, we conducted 60 semi-controlled experimental burns of representative biofuels (grass, shrubs, twigs/branches, litter, agricultural waste, and charcoal) from 4 regions of southern Africa (the savannas of Kruger National Park, South Africa and Etosha National Park, Namibia and the Miombo dambos and woodlands, respectively, of Zambia and Malawi). Emissions of CO_2; CO; CH_3Cl; CH_3Br; CH_3I; CH_4; CH_3COOH; HCOOH; CH_3COCH_3; CH_3CN; other non-methane hydrocarbons; NO_x ($NO + NO_2$); N_2O; NH_3; HNO_3; HONO; SO_2, HCl; total volatile inorganic Cl, Br and I; and particulate species (total C, total N, and water-soluble Cl^-, Br^-, NO_3^-, NH_4^+, SO_4^{2-}, $HCOO^-$, CH_3COO^-, $C_2O_4^{2-}$, PO_4^{3-}, Ca^{2+}, Mg^{2+}, K^+, and Na^+) were measured. The elemental compositions (C, N, Cl, Br, I, S, P, Ca, Mg, K, Na, and Hg) of biofuels and ash were also quantified. Results for a subset of reactive trace gases and particulate species will be presented. Data are available through the project web site (http://jurgenlobert.org/projects/mpi_safari/).

16:00 – 16:15
Estimating emissions of carbonaceous compounds from southern African fires: A re-analysis of modeling techniques
K. Caylor, C. Hely, S. Alleaume, R. J. Swap, H. H. Shugart

Abstract
When simulating emissions from biomass burning in Southern Africa for the SAFARI 2000, we detected what appears to be a systematic bias in the model used to predict the emissions of various carbon compounds from fires. The summation of carbon in the compounds released to the atmosphere during burning does not have a mass balance with the amount of carbon lost from the fuel sources in the ecosystem. One might expect minor inconsistencies in mass balance because empirical measurements of carbon compounds emitted by a fire are measured with some degree of sampling error. On the contrary, we find that the field measurements on which the model is derived do not exhibit any the persistent errors with respect to mass balance. A reanalysis of the data used to develop the emissions model indicates that the use of emission factors instead of emission ratios in model formulation is the most fundamental cause for the persistent bias observed. We also find that the use of a modeling methodology that independently relates the emission factors of multiple carbon-bearing compounds to fuel load in fires has led to an over-simplification of the ways in which the quantity of compound-specific emissions are co-limited through mass balance. Finally, our reanalysis reveals the presence of auto-correlation in the regressions used to estimate model parameters, and the removal of these auto-correlated parameters reduces the models explanatory power greatly. This leads to the conclusion that current data on fires in southern Africa are sufficient to support a dynamic model of emission ratios based on fuel composition for CO2 and CO only, and that constant emission ratios based on remaining mass balance are more appropriate for CH4, NMHC and PM2.5. We compare emissions estimates of southern African fires using both the previous emission ratio models and the new model derived from our reanalysis. We conclude that the new approach does a better job of constraining mass balance and provides similar regional results.

16:15 – 16:30
Coordinated airborne, spaceborne, and ground-based measurements of massive, thick aerosol layers during the dry season in southern Africa
B. Schmid, J. Redemann, P. B. Russell, P. V. Hobbs, D. L. Hlavka, M. J. McGill, B. N. Holben, E. J. Welton, J. Campbell, O. Torres, R. A. Kahn, D. J. Diner, M. C. Helmlinger, D. A. Chu, C. Robles Gonzalez, and G. de Leeuw

Abstract
During the dry-season airborne campaign of the Southern African Regional Science Initiative (SAFARI 2000), unique coordinated observations were made of massive, thick aerosol layers. These layers were often dominated by

aerosols from biomass burning. We report on airborne Sunphotometer measurements of aerosol optical depth (l=354-1558 nm), columnar water vapor, and vertical profiles of aerosol extinction and water vapor density that were obtained aboard the University of Washington's Convair-580 research aircraft. We compare these with ground-based AERONET Sun/sky radiometer results, with ground based lidar data (MPL-Net), and with measurements from a downward-pointing lidar aboard the high-flying NASA ER? 2 aircraft. Finally, we show comparisons between aerosol optical depths from the Sunphotometer and those retrieved over land and over water using four spaceborne sensors (TOMS, MODIS, MISR and ATSR-2).

16:30 – 16:45

Comparison of in-Situ observations of southern African aerosols to MODIS aerosol products during SAFARI 2000

R. J. Swap, D. L. Richardson, S. Alleaume, A. Chu, D. C. Stein, S. J. Piketh, H.J. Annegarn, and C. Ichoku

Abstract

Traditional validation and calibration of remotely sensed products often involves a direct comparison of radiation observations by satellites and either ground-based or in-situ radiometers. The approach this paper explores the relationships between remotely sensed aerosol products from Terra to in-situ observations made during SAFARI 2000. Emphasis is placed on the comparison of aerosol characteristics and concurrent trace gas observations onboard the South African Weather Service Aerocommander 690A research aircraft to atmospheric products derived from MODIS onboard the NASA EOS Terra platform. Changes in the relationships with height are explored as well.

16:45 – 17:00

Characterization of the optical properties of atmospheric aerosols over Inhaca Island, Mozambique

A. J. Queface, S. J. Piketh, H. J. Annegarn, B. N. Holben, R. J. Uthui and R. J. Swap

Abstract

Characterization of aerosol optical properties over southern Africa is needed for better understanding the impact of aerosols on regional climate change. CIMEL Sun Photometer measurements of aerosol optical thickness over Inhaca Island, Mozambique between April and November 2000 are analyzed. Comparisons with two other sites, Mongu, Zambia and Bethlehem, South Africa are made. The aerosol optical thickness observed at Inhaca Island indicates high turbidity. In ~50% of the measurements, aerosol optical thickness values are above 0.2, with an overall mean of 0.26 ± 0.19. The Angström exponent parameter has a wide range from 0.2 to 2, with a modal value of 1.6. This indicates a wide range in particle sizes and the dominance of fine mode aerosols at this site. Data from all three sites reveals seasonal variability, with a significant increase in aerosol content between August and October. This suggests a strong contribution of biomass burning to the aerosol content, since August-October is biomass burning season in Southern Africa. A north to south gradient in aerosol optical thickness is confirmed. The highest aerosol content is observed over Mongu, while Bethlehem has the lowest. The retrieved aerosol volume size distribution over Inhaca Island demonstrates that at high levels of aerosol optical thickness, accumulation mode aerosols dominate. In contrast coarse mode aerosols dominate when aerosol optical thickness is very low. It is noted that there is a tendency for decreasing particle size as aerosol optical thickness increases, with the peak in distribution of the accumulation mode volume radius decreasing from 0.19 μm at τ_a=0.42 to ~0.14 μm at τ_a=1.12.

17:00 – 17:15

Validation of Version-4 MODIS aerosol optical depth retrievals in SAFARI region

D. A. Chu, L. A. Remer, Y. J. Kaufman, C. Ichoku

Abstract

The MODIS aerosol optical depth (t_a) retrievals produced from "consistent year" production (or version 3) underestimate aerosol loading by as much as 50% for t_a > 1 when compared to AERONET sun photometer observations in source regions with fresh smoke (e.g., Zambia). In contrast, better agreement (within the MODIS retrieval error $\Delta\tau=\pm0.05\pm0.2\tau$) was found for MODIS-derived t_a in South Africa (e.g., Skukuza site) for aged smoke or smoke mixed with local pollution. The underestimated t_a values in source region were caused by stronger absorption (i.e. more soot particles) in South African biomass burning as compared to that in South America where the MODIS smoke aerosol model was based upon with single scattering albedos (ω_0)~ 0.9. To take into account the stronger absorption in biomass burning in the source regions, smaller single scattering albedos (ω_0 (0.47 μm) = 0.86; ω_0 (0.66 μm) = 0.85) are used in the MODIS version-4 data reprocessing. We will show a complete validation of MODIS-derived t_a using version-4 MODIS aerosol algorithm.

17:15 – 17:30

Calculations of aerosol radiative forcing in the SAFARI region from MODIS Data

L.A. Remer, C. Ichoku, Y.J. Kaufman, D.A. Chu

Abstract

The MODIS aerosol products, combined with the characterization made of the aerosol during SAFARI 2000 permits an accurate calculation of the aerosol radiative forcing at the top and bottom of the atmosphere. The combination of MODIS accuracy, coverage, resolution and the ability to separate fine and coarse mode make this calculation substantially advanced over previous attempts with other satellites. We focus on the oceans adjacent to southern Africa and construct an aerosol optical thickness histogram from MODIS data. The histogram suggests a conceptual model of a large particle oceanic background aerosol overlaid with an intrusion of fine mode aerosol of high optical thickness. We use a solar radiative transfer model to calculate the clear-sky fluxes at the top and bottom of the atmosphere. Aerosol properties are taken from SAFARI 2000 observations and climatology for the region. Calculations are made separately for fine and coarse mode aerosol and then combined using MODIS-derived values for the ratio between the modes. The forcing at the top of atmosphere is calculated to be -10 Wm^{-2}, while the forcing at the surface is –26 Wm^{-2}. These results resemble those calculated from INDOEX data, and are most sensitive to assumptions of aerosol absorption.

Wednesday October 9 2002

Morning Session: Atmospheric Processes and Transport

08:30 – 08:45

The meteorology, climate and air transport of southern Africa during SAFARI 2000

T. M. Freiman, M. R. Jury, H. Riphagen, S. Medcalf and R. J. Swap

Abstract

The daily atmospheric circulation and thermodynamic structure of the Southern African troposphere are examined during the Southern African Regional Science Initiative (SAFARI 2000) period of August and September. A combination of the climate, the meteorology and the resultant advection to and from various sites across Southern Africa identify the transport pathways and mixing of biomass burning related chemical species over and off the subcontinent and serve as a background for more detailed in situ observations. Aerosol and trace gas inputs to the atmosphere during the biomass burning season contribute to the ubiquitous haze layers over the subcontinent. The elevated absolutely stable layers, which trap airborne material below their bases, were found, as in past studies, to be frequent, persistent (on average every four out of five days) and spatially continuous south of 20ºS during August-September 2000. Over the interior plateau (south of 20ºS), anticyclonic conditions associated with large-scale subsidence and surface divergence dominate in the lower troposphere (64 %) while baroclinic westerly waves are most pronounced in the middle troposphere (67 %). Further north, tropical easterly winds were predominantly weak during August, resulting in the transport and accumulation of airborne material over Angola much of the time, with occasional bursts of easterly flow resulting in transport out over the tropical Atlantic Ocean. Mid-latitude troughs swept through during September 2000 causing substantial dilution and southeastward anticyclonic circulation events. The dominant modes of transport over Southern Africa, determined using trajectories (input data at 0.5º resolution), were direct westerly transport toward the Indian Ocean and recirculated transport. Recirculated (direct westerly) transport occurred most (least) frequently, more than 60 % (less than 20 %), in the lower troposphere (850-800 hPa) and weakened (intensifies) with height, to reach a minimum (maximum) frequency of occurrence in the mid-troposphere (500-400 hPa). The analyses that will be presented will provide a useful background to other data collected during SAFARI2000 on land-atmosphere interactions and observations.

08:45 – 09:00

Tropospheric ozone over southern Africa during SAFARI 2000: Transport pathways and associated synoptic features

P. M. Bundi, S. J. Piketh, A. M. Thompson, H. J. Annegarn

Abstract

The focus of this paper is to investigate the influence of meteorological conditions on tropospheric ozone over southern African subcontinent during the SAFARI 2000-campaign. The tropospheric ozone datasets used in this study were measured using the South African Weather Service (SAWS) research aircraft, Aerocommander, 690A, JRA and JRB, between 13 August and 26 September 2000. Other complimentary measurements used for the study are ozonesonde datasets collected at Irene, Pretoria and Nairobi, Kenya. The results reveal that during biomass burning season, in which SAFARI 2000 was conducted, tropospheric ozone values as high as 70 ppbv were observed within the haze layers in Zambia and Mozambique. The ozone concentrations in August were relatively lower for a burning season, compared to September O_3 values. The highest concentration of tropospheric ozone detected by the ozonesonde instrument was on 4 September, with maximum values of 70 ppbv over Irene. The highest ozone value in Nairobi (73 ppbv) was observed in late August. The results show evidence of high tropospheric ozone episodes, linked to strong surface pressure systems over both Southern Atlantic and within the Indian Ocean, coupled with deep continental surface trough and persistent subcontinent subsidence during the August-September period. The first week of September had the highest concentrations of ozone at layers confined between 1 and 2-km. Ozone accumulation was triggered by regional inversion layers below which photochemical production of ozone took place. The trajectory transport pathways show recirculation patterns through Mozambique and back to the subcontinent. In general, during the study period, the levels of ozone concentrations over southern Africa were higher than the ozone levels measured over Kenya, an equatorial country. The enhanced concentrations of ozone over southern Africa was caused by intense biomass burning activities confined south of the equator and the nature of transport pathways of ozone and its precursor gases (re-circulation) over the subcontinent.

09:00 – 09:15

Lusaka, Zambia, during SAFARI 2000: Evidence for convergence of local and imported ozone pollution

A. M. Thompson, J. C. Witte, T. M. Freiman, N. A. Phahlane and G. J. R. Coetzee

Abstract

It is well known that during August and September, throughout south central Africa, seasonal clearing of dry vegetation and other fire-related activities lead to intense smoke haze and ozone formation. The first ozone soundings in the heart of the southern African burning region were taken at Lusaka, Zambia (15.5S, 28E) in early September 2000. In addition to rural seasonal burning, that produces an ozone pollution background at Lusaka, local practices wood fuel burning for cooking, charcoal manufacture, roadside clearing, and vehicular traffic contribute to ozone in this more urbanized setting. Maximum surface ozone at Lusaka was therefore over 90 ppbv and column tropospheric ozone exceeded 50 DU. These values are higher than concurrent measurements over Nairobi (1S, 38E) and Irene (25S, 28E, near Pretoria). At least 30% of Lusaka surface ozone appears to be from the local sources. A layer at 800-500 hPa has ozone > 120 ppbv and originates from trans-boundary recirculation. Starting out over Zambia, Angola, and Namibia, ozone-rich air travels east to the Indian Ocean, before heading back toward Mozambique, Zimbabwe and Zambia. Thus, Lusaka collects local and imported pollution, at the surface and just above the mixed layer, consistent with its location within the southern African gyre.

09:15 – 09:30

Biomass burning and anthropogenic aerosol effects on cloud microphysics and precipitation development

R. T. Bruintjes

Abstract

Recent experiments studying the effects of biomass burning, anthropogenic, and dust aerosols have indicated that aerosols can significantly alter the radiative characteristics of the atmosphere. In addition, it has been shown that especially biomass and industrial pollution aerosols can also affect cloud microphysical processes that contribute to the indirect radiative effects of clouds. Aerosols are important for cloud formation because they provide the cloud condensation nuclei (CCN) and ice nuclei for droplets and ice crystals to form on. Depending on the chemistry, size and concentrations of these aerosols the efficiency of precipitation formation in clouds could be either enhanced or inhibited, especially with respect to CCN and the formation of cloud droplets. Recent results from biomass burning experiments have indicated that the chemistry of particles initially emitted from fires undergo chemical transformations in the atmosphere that affect both the chemical composition and the size of the particles (Li et al, 2003). More KCl particles occur in young smoke (Fig. 1), whereas more K_2SO_4 and KNO_3 particles are present in aged smoke. This change indicates that KCl particles from the fires were converted to K_2SO_4 and KNO_3 through reactions with S- and N-bearing species from biomass burning as well as other sources (Fig. 2, Li et al., 2003). These chemical reactions seem to be similar to those observed in polluted marine environments as reported by McInnes et al. (1994). The chemical transformations lead to differences in CCN activity between fresh smoke and aged smoke and therefore to differences in CCN and cloud characteristics (Bruintjes et al, 2003). The talk will provide an overview of the *in-situ* measurements during SAFARI-2000 and assess the impacts on cloud microphysics and precipitation processes in clouds. The possible implications for rainfall enhancement experiments utilizing hygroscopic salts will also be discussed.

09:30 – 09:45

Cloud condensation nuclei and cloud processes over southern Africa

K.E. Ross, S.J. Piketh, R.T. Bruintjes, R.P. Burger and V. Salazar

Abstract

Cloud condensation nuclei (CCN) emitted as a result of fossil fuel burning and other human activities alter cloud droplet spectra, which in turn affects cloud albedo and precipitation efficiency. In southern Africa, industries and power plants clustered on the South African Highveld are a significant year-round source of anthropogenic aerosols, and biomass burning, which occurs predominantly in the tropics, injects large quantities of particles into the atmosphere at the end of the dry season (July to October). Aerosol-cloud interactions have been investigated using in-situ aerosol, CCN and cloud measurements collected from the South African Weather Service's Aerocommanders during the Aerosol Recirculation and Rainfall Experiment (ARREX) and during the Southern African Regional Science Initiative SAFARI 2000. Wet season campaigns were conducted in January 1999 and March 2001, and the dry season campaign was conducted in August/September 2000. CCN concentrations are generally higher in the late dry season than in the wet season; highest concentrations are found in the northern regions of the subcontinent due to the burning of savanna biomass. South of 20°S, industrial emissions are sufficient to account for CCN levels throughout the year. Multiple inversions and absolutely stable layers control the stratification of aerosols and CCN.

Biomass burning particles are efficient CCN, and the median diameter of the accumulation mode is large (up to 0.19 µm). Recently-emitted industrial aerosols are less soluble and have a smaller median diameter (0.11 µm). Twice as many aerosols act as CCN in the dry season (68%) than in the wet season (34%). The fraction is highest in the dry season over the tropical regions (>80%), where smoke aerosol predominates.It is hypothesized that industrial aerosols have the greatest impact on cloud properties downwind of the Highveld, while biomass burning emissions mainly modify clouds in the northern regions of the subcontinent at the beginning of the wet season. A cloud parcel model is used to investigate the effect of aerosols in different environments on droplet spectra in warm clouds. In particular, the microphysical properties of clouds that form in unpolluted environments are compared with clouds that form in airmasses contaminated with industrial or biomass burning aerosols. It is found that high concentrations of accumulation mode particles retard precipitation production, and the time taken for the onset of coalescence is significantly delayed in polluted airmasses. Furthermore, modelling results suggest that the presence of even very low concentrations of giant CCN effectively stimulate coalescence, even in highly polluted conditions.

09:45 – 10:00
MODIS cloud science and validation activities during SAFARI 2000
S. E. Platnick, M. D. King, and T. Arnold

10:00 – 10:15
Satellite Remote Sensing of Industrial Atmospheric Emissions
C. Rautenbach, H.J. Annegarn, M.A. Kneen

Abstract

Long-range transport of atmospheric emissions from coal-fired power plants on the Highveld takes place over thousands of kilometers across southern Africa. Various empirical and computational techniques have been applied to investigate the patterns of transport and deposition of these emissions, including wet deposition monitoring, passive diffusion monitors, airborne *in situ* measurements, trajectory and coupled chemistry trajectory models. While all these methods have certain advantages, there has been a lack of a means of direct observation that is extensive in both time and space. Past satellite sensors have been used to track and quantify gaseous emissions such as Sulphur Dioxide (SO_2), Nitrogen Dioxide (NO_2) and Ozone (0_3) but with relatively low spectral and temporal resolution. The multi-spectral Thermal Infrared (TIR) capabilities of NASA's Terra satellite will offer new tools for observing the primary and secondary particles from natural and industrial emissions with moderate spatial and temporal resolution. The emissions from coal-fired power stations are of particular interest to this project as they are considered a large source of primary SO_2 and secondary sulphate particles. The absorption spectrum of the SO_2 molecules exhibit ultraviolet, infrared and microwave bands that are amenable to remote sensing techniques. This paper will evaluate the potential of detecting SO_2 emissions from space using data from the sensor on Terra known as the Advanced Spaceborne Thermal Emission and Reflectance Radiometer (ASTER). The thermal infrared image data and the SO_2 absorption spectra acquired from these images will be used to detect the presence of SO_2 near industrial processes and in downwind impact areas. ASTER's thermal bands in the 8 - 12 µm window region will be used to extract an SO_2 signal from ASTER satellite images over three power stations in South Africa. The software used to carry out these operations will be introduced and the series of processes required to detect SO_2 plumes will be discussed. An overview of previous work on volcanic SO_2 detection will be shown and the preliminary results of industrial SO_2 detection from ASTER data will be presented.