IGACtivities Newsletter

of the International Global Atmospheric Chemistry Project

A Note From the IGAC Chair: *Guy Brasseur*

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In this Issue

IGAC Project Offices

One of the main tasks of IGAC is to facilitate international cooperation within the atmospheric chemistry community, and to coordinate large scientific initiatives such as field campaigns or other projects. To accomplish these tasks, IGAC has established several Project Offices in different parts of the world.

The main Core Project Office (CPO) is located at MIT in Cambridge, MA, USA and is headed by Dr. Alex Pszenny (pszenny@mit.edu). It forms the center of the IGAC network, and is the official link between the IGAC Scientific Steering Committee (SSC) and the large international group of IGAC scientists. The CPO also serves as an easily accessible source of information about past, current, and future scientific activities. It publishes this *IGACtivities Newsletter* and maintains a web site (http://web.mit.edu/igac/www/). A major task for the CPO for the next two years will be to help conduct an integration/synthesis project that will summarize the major accomplishments by our scientific community over the last decade and will provide a strategic view for future research. This effort will be coordinated by Ms. Harriet Barker (harriet@ucar.edu). The CPO is currently supported by several funding agencies in the US including NSF, NASA, and NOAA.

A European IGAC Project Office, headed by Dr. Stanislaw Cieslik (stanislaw.cieslik@jrc.it) is located in Ispra, Italy, at the Joint Research Centre (JRC) of the European Commission (EC). This regional office facilitates the participation of European scientists in IGAC and related activities, and coordinates the EC-sponsored research with IGAC Activities. I am pleased to announce that a new agreement between the European Commission and IGAC was recently signed to support this office for the period covering the 5th EC Framework Programme for Research and Technological Development.

Another regional IGAC office is located at the National Physical Laboratory in New Delhi, India, and is directed by Dr. D.C. Parashar (parashar@csnpl.ren.nic.in). This office coordinates activities conducted in South Asia (where issues related to global change are receiving increasing attention) and promotes a number of international workshops in the area of atmospheric chemistry.

All these offices play a major role in the success of IGAC. The role of the Project Officers is crucial. I would like to thank them for their hard work and their commitment to IGAC and to our discipline.

The present issue of *IGACtivities* focuses on the role of biomass burning in the global and regional budgets of chemical compounds of the atmosphere. Biomass burning, which is often the result of agricultural practices and of other human interventions, is a major source of atmospheric pertubations, particularly in the tropics. Several field campaigns, sponsored by IGAC's *Biomass Burning Experiment* (BIBEX) Activity, have produced a wealth of new information that is summarized in the following pages. I would like to thank Prof. M.O. Andreae, who recently stepped down as Convenor of BIBEX, and his colleagues for their important contribution to IGAC science. I am sure that BIBEX will continue to thrive under leadership of its new Conveners: Johann G. Goldammer of the Max-Planck-Institut für Chemie in Mainz/Freiburg, Germany, and Joyce Penner of the University of Michigan in the USA.

GLOBAL IGBP CHANGE

Science Features

The IGAC *Biomass Burning Experiment* (BIBEX): Rationale and Evolution

Contributed by **Meinrat O. Andreae**, *BIBEX Convener 1988–1998, Biogeochemistry Department, Max Planck Institute for Chemistry, Mainz, Germany*

While a few pioneering papers on the impact of biomass burning on the chemistry of the atmosphere were published in the late 1970s and early 1980s (e.g., Crutzen *et al.*, 1979), it is only in the last decade that fire has been recognized as a major source of important trace gases and aerosol particles to the world atmosphere. The rapid development of this field is reflected in a sharp increase in the rate of publications on biomass burning, starting about 10 years ago (Figure 1).

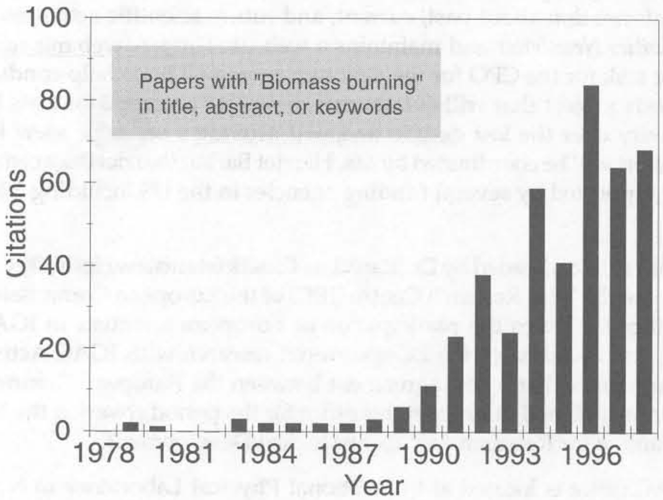

Figure 1. Papers with "Biomass burning" in the title, abstract, or keywords between 1978 and 1998.

Fire must have been around ever since land plants evolved some 300–400 million years ago. Before the advent of humans, fire was ignited naturally by lightning strikes in dry vegetated regions. Today, however, fire is almost exclusively the result of human activities, which include the burning of forested areas to facilitate land clearing, the burning of harvest debris, the extensive burning of natural grasslands and savannas to sustain nomadic agriculture, and the burning of biomass as fuel for cooking and heating.

Fires and smoke in Indonesia, Florida, Brazil, and other regions have been all over the news recently. The general public, as well as the scientific community, is now aware that the emissions from biomass burning represent a large perturbation to global atmospheric chemistry, especially in the tropics. Satellite and airborne observations have revealed elevated levels of O_3, CO, and other trace gases over vast areas of Africa, South America, the tropical Atlantic, the Indian Ocean, and the Pacific. Smoke aerosols from fires perturb regional, and probably global, radiation budgets by their light-scattering effects and by their influence on cloud microphysical processes.

Fire also has both short- and long-term effects on trace gas emissions from affected ecosystems, which, for instance, in the case of CO_2 and N_2O, may be more significant than their immediate release during burning. Fire also alters the long term dynamics of the cycling and storage of elements within terrestrial ecosystems, thereby changing their potential as sources or sinks of various trace gases. Finally, deposition of compounds produced by biomass burning on pristine tropical ecosystems may affect their composition and dynamics.

When, in November 1988, some fifty atmospheric scientists met at Dookie College, a small campus in the agricultural lands of Victoria (Australia) to map out the scientific goals of the International Global Atmospheric Chemistry (IGAC) Project, they were keenly aware of the prominent role that biomass burning plays in the tropics. Given the scarcity of data at the time, they assigned high priority to the creation of the IGAC *Biomass Burning Experiment* (BIBEX) with the goals to

1) characterize the production of chemically and radiatively important gases and aerosol species from biomass burning to the global atmosphere,
2) assess the consequences of biomass burning on regional and global atmospheric chemistry and climate
3) determine the short- and long-term effects of fire on post-fire exchanges of trace gases between terrestrial ecosystems and the atmosphere, and
4) understand the biogeochemical consequences of atmospheric deposition of products of biomass burning.

The first meeting of the BIBEX Coordinating Committee took place in September 1990, in Chamrousse, France. Additional meetings have been held approximately once per year, often in conjunction with IGAC symposia or other appropriate scientific meetings. The BIBEX community has also been involved in organizing several workshops and symposia, which served as platforms to review existing information, report on recent research, and plan future BIBEX activities. Examples are the 1992 Dahlem conference on Fire in the Environment (Crutzen and Goldammer, 1993), and the two Chapman Conferences on Biomass Burning (Levine, 1991; Levine, 1996)

As with all IGAC Activities, BIBEX utilizes and builds on existing international programs with common goals. In its activities, BIBEX focuses on biomass burning in the tropics, but also considers extratropical fire regions when appropriate. It has developed STARE (*Southern Tropical Atlantic Regional Experiment*) and FIRESCAN (*Fire Research Campaign Asia-North*) as BIBEX programs, has contributed to EXPRESSO (*EXPeriment for REgional Sources and Sinks of Oxidants*), and is participating in LBA (*Large Scale Biosphere-Atmosphere Experiment in Amazonia*). BIBEX will continue to adopt or initiate new programs in the future, with an increasing emphasis on quantifying the global distribution of biomass burned and the interaction of vegetation fires with human activities. Reflecting this change in focus, I have recently passed the Convener's torch to BIBEX's new Co-Conveners, Joyce Penner and Johann G. Goldammer.

There is a large number of publications based on BIBEX research, and numerous ongoing activities, more than can be presented in this newsletter. For those of you interested in knowing more, or maybe even to become involved, I invite you to visit the BIBEX homepage at http://www.mpch-mainz.mpg.de/~bibex/. Maybe I'll see you around a fire some time…

Editor's Note: Reference lists have been omitted from all articles due to space limitations. They are available on the IGAC web site (http://web.mit.edu/igac/www/) or in hardcopy upon request from the IGAC Core Project Office (igac@mit.edu).

The Southern Tropical Atlantic Region Experiment (STARE): TRansport and Atmospheric Chemistry near the Equator-Atlantic (TRACE-A) and *Southern African Fire/ Atmosphere Research Initiative* (SAFARI)

Contributed by **Meinrat O. Andreae**, *Biogeochemistry Department, Max Planck Institute for Chemistry, Mainz, Germany and* **Jack Fishman**, *NASA Langley Research Center, Hampton, Virginia, USA*

The southern tropical Atlantic region, defined here as the region containing the Amazon basin, the tropical South Atlantic, and southern Africa, was an obvious choice for the first major BIBEX field campaign. Large tropical forest and savanna fires occur in this region every year. In addition, observations from satellites and the space shuttle had shown high levels of tropospheric ozone and carbon monoxide to be present over this region annually in the August to October period (Fishman *et al.*, 1990). In spite of the low degree of industrialization in this region, the area of high O_3 during austral spring is at least as large as the O_3 plumes emanating from North America, Europe, and Asia (Figure 1). Results from previous campaigns (e.g., ABLE-2A, CITE-3, and DECAFE-88) also suggested a widespread impact of vegetation fires on both continents on the trace gas and aerosol content of the troposphere.

The *Southern Tropical Atlantic Region Experiment* (STARE) evolved from the designs for a collaborative project between Brazil and NASA, which had been proposed under the title *TRansport and Atmospheric Chemistry near the Equator-Atlantic* (TRACE-A) as part of NASA's *Global Tropospheric Experiment* (GTE). TRACE-A was designed to investigate by *in situ* measurements the extent, characteristics, and origin of the South Atlantic O_3 enhancement, and to assess the role of emissions from Africa and Brazil. Its primary goal was to determine the impact of fire emissions on scales that ranged from regional (~100 km) to quasi-global (>1000 km).

At the same time as TRACE-A was being developed, a team of African, European, and American scientists came together in order to investigate the emissions from fires and soils in southern Africa, the meteorology over the subcontinent and the ecological impact of fires in the African savannas. This project, named *Southern African Fire/Atmosphere Research Initiative* (SAFARI), became, together with TRACE-A, the *Southern Tropical Atlantic Region Experiment* (STARE). SAFARI and TRACE-A complemented each other both in terms of scientific disciplines and of scales of interest. Thus, the combined missions provided a comprehensive multi-disciplinary experiment that spanned spatial scales from less than 1 km to more than 1000 km to provide insight into the potential impact of biomass burning on the atmospheric and terrestrial environment.

In spite of many political, administrative, logistical, technical, and meteorological obstacles, both teams, TRACE-A and SAFARI, managed to get into the field in the second half of 1992. TRACE-A involved some 200 scientists from the United States, Brazil, Congo, South Africa, and Great Britain. Its research was centered around the NASA DC-8 instrumented research aircraft. More than 150 scientists from 14 nations (Germany, South Africa, Zimbabwe, Zambia, Namibia, Swaziland, Congo, Brazil, Belgium, France, Great Britain, Canada, and the USA) participated in SAFARI, which involved several aircraft, ground-based operations, and remote sensing. STARE's interdisciplinary character was reflected by the involvement of research groups from atmospheric chemistry, meteorology, climatology, biogeochemistry, and fire ecology, as well as forestry, soil science, pasture science, and microbiology. Some key results from STARE will be pre-

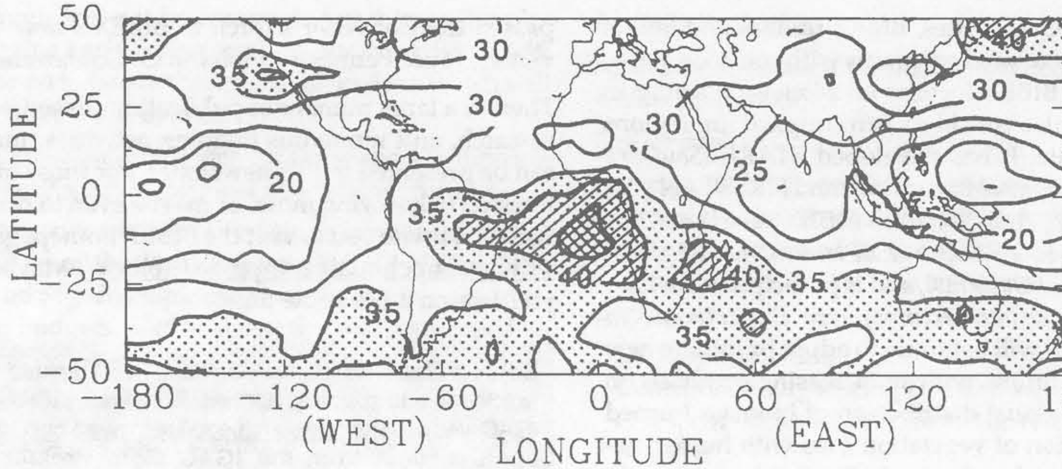

Figure 1. The climatological distribution of integrated tropospheric ozone determined from satellite data for the month of October. The stippled, hatched, and crosshatched areas indicate regions where more than 35 Dobson Units of ozone are present in the troposphere (from Fishman, 1994).

sented in the following paragraphs. More information can be found in a special issue of the *Journal of Geophysical Research* (Volume 101, No. D19, 1996).

Fire behavior, fire ecology and ground-based emission measurements, including fire and soil emissions

A central objective in SAFARI was to conduct an integrated study of fire and its effects, including fire behavior and ecological responses, as well as the emissions from the fires and from soils impacted by burning. Energy release measurements and convection column monitoring showed that savanna fires, unlike boreal forest fires with their greater fuel loads, are unable to generate sufficiently high, sustained energy releases to produce convection columns above 3–4 km. Therefore, their emissions are confined to the lower troposphere, unless they become entrained by independently generated large-scale convective activity, e.g., after transport into the ITCZ region. Extensive measurements of fuel biomass, combustion factors, fire behavior, and emission factors were made in savannas, grasslands, and woodlands in South Africa and Zambia. As a result of this work, combined with previous studies in other savanna regions, we now have a very accurate and comprehensive inventory of emission factors from savanna fires, probably the best for any ecosystem (Cachier *et al*, 1996; Lacaux *et al.*, 1996; Andreae, 1997; Koppmann *et al.*, 1997). Scaling techniques developed under SAFARI made it possible to derive regional emission estimates based on these emission factors and on fire detection by remote sensing. The results showed large differences to previous assessments, mostly due to much lower estimated amounts of biomass burned.

Studies of soil emissions of trace gases during SAFARI-92 concentrated on NO, NO_x, and N_2O, and on trace carbon gases. Highest emission rates in the absence of burning were related to high soil total N content and N nitrification rate. Seasonal variations in NO emissions were ascribed to the effect of seasonally-varying rainfall on soil water contents (Levine *et al.*, 1996). It is suggested that African savanna soils can provide a significant source of NO either with or without burning, depending on their moisture status and the seasonal timing of rainfall events. Soil fluxes of CO_2 measured during SAFARI-92 in the semi-arid savanna of the Kruger National Park showed little influence of burning, but were also strongly affected by the availability of moisture (Zepp *et al.*, 1996), increasing by an order of magnitude with heavy rain and maintaining elevated values for at least a week. In contrast, CO fluxes (which were considerably higher than those previously measured in southern African savannas) were insensitive to moisture changes, but responded positively to burning.

Airborne sampling of trace gases and aerosols

In addition to a focused study during September–October 1992, atmospheric measurements during STARE included enhanced and coordinated ozonesonde and rawinsonde launches from sites spanning the tropical Atlantic region. During this period, measurements were made using the NASA DC-8 aircraft, two Brazilian and five South African aircraft (with international science crews), as well as a series of ground-based stations on both continents.

TRACE-A's primary platform was the NASA DC-8 "Flying Laboratory", with a suite of *in situ* instruments that measured NO, NO_x, nonmethane hydrocarbons, H_2O_2, CH_3O_2H, CO, CH_4, N_2O, PAN, O_3, C_2Cl_4, PPN, HNO_3, some organic acids, and remote sensing capabilities for the measurement of ozone and aerosols above and below the airplane. As a reference point against which to study the impact of fire emissions, TRACE-A also characterized pristine air by flying as far south as possible off the east coast of South America to find an airmass that had not recently been influenced by continental emis-

Species	Molar emission ratio [10^{-3}]	Emission factor g species/kg dry matter	African savanna	Global savanna	Biomass burning	All anthrop. sources
			Tg species per year			
CO	62	65	130	240	680	1600[1]
CH_4	4	2.4	5	9	43	275[1]
NMHC	6	3.1	6	11	42	100[2]
NO_x[b]	2.8	3.1	6	11	21	70[1]
N_2O	0.09	0.15	0.30	0.56	1.3	5.5[1]
NH_3	1.5	1	2	3.7	6.7	57[3]
CH_3Cl[a]	0.95	0.11	0.22	0.41	1.1	1.1?
CH_3Br[a]	0.0083	0.002	0.004	0.007	0.019	0.11[7]
Aerosols						
TPM		10	20	37	90	390[4]
Carbon		7	14	26	60	90[4]
BC		0.8	1.6	3	9	20[4]

[a] emission ratios relative to CO; [b] as NO

[1] Houghton *et al.*, 1995; [2] Ehhalt *et al.*, 1986; [3] Schlesinger and Hartley, 1992; [4] Andreae, 1995

Table 1. "Best guess" emission factors and emission ratios for savanna fires, and estimates for emissions from African and global savanna fires, all biomass burning, and all anthropogenic sources (including biomass burning).

sions. During the southernmost portions of this flight, NO_x < 18 ppt, CO < 65 ppb, CH_3CL < 600 ppt, and C_2H_2 < 45 ppt were measured (Talbot *et al.*, 1996) indicating that the air had likely not been influenced by continental emissions for more than 10 days. A synthesis of the measurements from these instruments was then used to characterize the emissions from the continents, to understand the photochemical processes taking place in the atmosphere downwind from the emissions, and eventually to glean insight into how these emissions and subsequent photochemistry impacted the global scale aspect of the composition of the troposphere.

A significant component of TRACE-A included a suite of investigations fielded by the Brazilian Space Agency, INPE, in collaboration with other Brazilian agencies and universities. The Brazilian investigations consisted of two aircraft instrumented for measurements of trace gases (CO, O_3, N_2O, CH_4, and CO_2), radon, and aerosols (black carbon), respectively. These aircraft obtained vertical profiles of these species in addition to defining spatial gradients within Brazil during survey and transit flights (Kirchoff and Alvalá, 1996). Surface measurements of these species were made within the region generally affected by biomass burning at three ground sites.

The DC-8 flights in Brazil were designed to accomplish the primary objectives of characterizing the composition of air exiting the continent that had been influenced by local sources, characterizing the composition of air that had been recently impacted by continental emissions, and also obtain some measurements of air very near the source regions (i.e., fires). An additional "objective of opportunity" was to make a measurement of air that had been recently transported from the boundary layer to the upper troposphere by convection. One of the flights successfully captured this opportunity and found CO mixing ratios enhanced by more than a factor of three (200–300 ppb *vs.* 90 ppb) at altitudes of 9–12 km and clear signals of lightning-generated NO_x. It has been shown that the combination of convection and subsequent transport at high altitudes is important for contributing to the high ozone concentrations found over the southern tropical Atlantic (Pickering *et al.*, 1996).

The prolonged 1991/92 drought in southern Africa, called by many the worst drought of the century, resulted in less biomass loading throughout the region and, therefore, probably reduced the amount of burning relative to what would have taken place during a more representative year. In Kruger Park, South Africa, the focal point of the SAFARI campaign, vegetation was so sparse in most places that it was questionable for some time if the planned experimental burns even could take place. But eventually a region in the southern part of the park was found that was suitable for burning, and a series of experimental fires was conducted. These fires were investigated by three of the SAFARI aircraft: a DC-3, a Cessna 182, and a Bell helicopter. All had been equipped with instruments for trace gas and aerosol measurement and sampling. The DC-3 payload included instruments for the determination of O_3, NO, NO_x, NO_y, CO_2, CH_4, NMHC, and aerosols. From the flights into the plumes of the experimental fires as well as numerous fires of opportunity came a comprehensive characterization of the emission characteristics of savanna fires.

Following the plume flights, the DC-3 undertook two "grand tours" of southern Africa, to map the impact of biomass smoke over the subcontinent, spanning the countries of South Africa, Zimbabwe, Zambia, Namibia, Swaziland, Angola, and Botswana. This work was

Reference lists are available at http://web.mit.edu/igac/www/.

complemented by detailed O_3 studies over Namibia by a Learjet aircraft. The NASA DC-8 traveled to northern Zambia (~1300 km) to find a region of widespread burning. Charred expanses of burnt area were observed and were indicative of the widespread nature of the recently burned areas throughout the study area. In these polluted regions, high concentrations of many trace gases were encountered up to altitudes of ~3000 m. Ozone generally ranged from 60–100 ppb; NO, 0.15–0.20 ppb; NO_2, 1.1–1.4 ppb; PAN, ~4 ppb; H_2O_2, ~5 ppb; HNO_3, ~1 ppb; HCOOH, 7–8 ppb; and CH_3OOH, 0.7-0.8 ppb (for further details, see Gregory *et al.*, 1996; Harris *et al.*, 1996; Heikes *et al.*, 1996; Jury *et al.*, 1996; Singh *et al.*, 1996; Smyth *et al.*, 1996; Talbot *et al.*, 1996; Thompson *et al.*, 1996; Zenker *et al.*, 1996). Aerosols, hydrocarbons, CO, CH_4, N_2O, and CO_2, were also elevated well above their background concentrations (Anderson *et al.*, 1996; Blake *et al.*, 1996; Le Canut *et al.*, 1996; Maenhaut *et al.*, 1996). Although O_3 concentrations were high in the same region as the most intense smoke, higher mixing ratios were observed above the boundary layer (Figure 2). In a layer generally situated between 4–7 km, the UV-DIAL measured mixing ratios were often in the 80–120 ppb range (Browell *et al.*, 1996). In addition to biomass burning, large NO emissions from savanna soils following rain showers were found by the DC-3 during a flight over Namibia (Harris *et al.*, 1996).

Regional meteorology and transport of pyrogenic emissions and their reaction products

Meteorological and climatological work in SAFARI was focused on defining the fields of motion at various scales, from the turbulent to the synoptic and planetary, which influence fires and determine the dispersion and transport of pyrogenic emissions. During spring, anticyclonic flow is dominant over the subcontinent south of 15°S, and the atmosphere is characterized by inversions and stable layers that inhibit the development of penetrative moist convection and thus trap pyrogenic material in the lower atmosphere. Once burning products break through the mixed layer they are again trapped by mid-tropospheric stable layers (Garstang *et al.*, 1996). In many instances, smoke-laden airmasses in the region were quite old and had recirculated for several days over the continent before being advected to the Indian or Atlantic Oceans (Swap *et al.*, 1996; Tyson *et al.*, 1996). Emission to the Indian Ocean tended to be at higher altitudes, whereas the flow to the Atlantic was usually trapped in the lower few kilometers of the troposphere.

Flights over the tropical South Atlantic were conducted to answer the overriding question of how much of the ozone enhancement is a result of *in situ* generation and how much is the result of advection from either South America or southern Africa, or both. Photochemical calculations were performed using the *in situ* DC-8 measurements as input. Calculations near the source regions indicate that photochemical generation of ozone in the lower atmosphere on the regional scale (100–1000 km) near sources of biomass burning are comparable to the

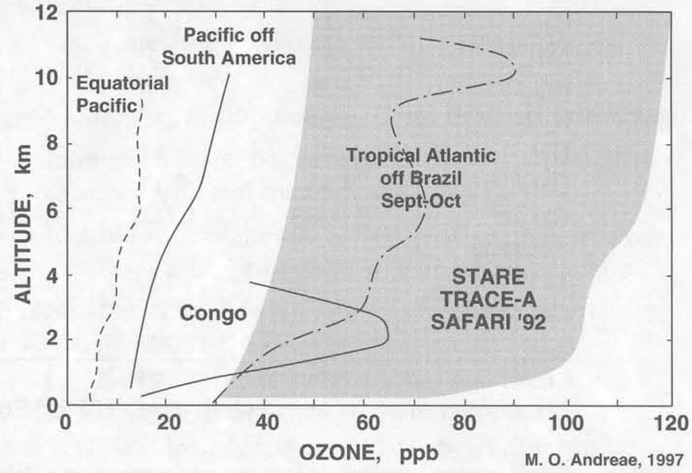

Figure 2. Vertical distribution of ozone in the tropics. There is no biomass burning influence evident over the equatorial Pacific, some influence of transport off the west coast of South America, and strong O_3 enrichment by photochemical production in biomas burning plumes over Brazil and the Congo. The STARE data (shaded) are the highest regional ozone levels recorded anywhere in the tropics and subtropics to date.

amount of regionally generated ozone over industrialized regions at temperate middle latitudes during summertime (Mauzerall *et al.*, 1998).

Perhaps the most important finding is the ubiquitous nature of ozone generation in the upper tropical troposphere, where integrated ozone production is calculated to be $>1 \times 10^{11}$ mol. cm^{-2} s^{-1} between 8–12 km. This large net photochemical production in the upper troposphere offsets the photochemical destruction of ozone within the tropical marine boundary layer. Correlation of NO_y with CO suggests that biomass burning was an important source of NO_x at all altitudes during TRACE-A. There is also evidence that NO_x throughout the TRACE-A region was recycled from its oxidation products rather than directly transported from its primary sources. The low HNO_3 mixing ratios observed above 8 km suggest a rapid mechanism of HNO_3 to NO_x conversion, not usually considered in current models Jacob *et al.*, 1996). Mixing ratios of peroxides and formaldehydes (byproducts of hydrocarbon oxidation and indicators of the oxidizing capacity of the troposphere) were fairly well simulated by the photochemical calculations. Discrepancies between the calculated mixing ratios and ratios among the species point to possible deficiencies in our understanding of the chemical mechanisms by which these compounds are generated in the atmosphere.

Satellite Fire Monitoring: A Status Report

Contributed by **Chris Justice**, *IGBP-DIS, Global Environmental Change Program, Department of Environmental Sciences, University of Virginia**

** This article includes contributions from* **Luke Flynn**, *University of Hawaii;* **Ned Dwyer**, *Joint Research Center, Ispra;* **Olivier Arino**, *European Space Agency;* **Chris Elvidge**, *NOAA;* **Yoram Kaufman**, *NASA/GSFC;* **Jose Pereira**, *Tapada da Ajuda, Lisbon.*

The global media reporting of recent wildfire events in Indonesia, Mexico, and the USA associated with extreme weather conditions has led to a renewed interest in satellite fire monitoring. Questions are being asked concerning the ability to monitor fires using satellite remote sensing and the impact of these fires on human health, atmospheric composition, and ecosystem disturbance.

The risk to human livelihood posed by fires and the large economic cost of extreme fire events is leading disaster-management agencies to evaluate their monitoring and management response systems. The satellite component of these early-warning systems is focussed on securing near real-time information on the susceptibility of vegetated landscapes to fire, the early identification of fires and the tracking of fire information systems needed by fire managers, which include weather data, field and aircraft reports, and fire prediction and management response models.

The global change research community has rather different requirements for satellite data. Their focus is to quantify the location, areal extent and intensity of fire events, their return frequency, and associated aerosol and trace gas emissions. Global change researchers are also concerned with the impacts of fire on ecosystem disturbance, on nutrient cycling, and on the surface radiation budget and their associated feedbacks. Global change research questions which are getting increasing attention involve quantifying and predicting changes in fire frequency associated with variability and trends in climate conditions and human population dynamics, and the likely impacts on trace gas and particulate release, ecosystem function, land management, and biological conservation.

At the Dahlem Conference on Fire in the Environment in 1992 some members of the BIBEX community articulated a goal for a Vegetation Fire Information System that would provide the underpinning data for BIBEX research. Through the activities of the IGBP-DIS Fire Working Group there has been a concerted effort to move towards this goal by making available samples of regional data from existing satellite sensing systems and developing a Global Fire Product using daily data from the NOAA AVHRR sensing system (http://www.cnrm.meteo.fr:8000/igbp/index.html).

The Fire Working Group has also promoted the global change research requirements with the space agencies. There is an increasing availability of data from existing satellite systems and new sensing systems are being designed with fire monitoring specifications.

Current sensing systems can be used to generate products of fire susceptibility using time-series of vegetation state, the occurrence and location of active fires using middle and thermal infrared sensors, and smoke and area burned using visible and near and middle infrared sensors. Microwave sensors can also be used to identify burned areas. The current sensors that provide these have different spatial resolutions and different overpass times and repeat frequencies, resulting in very different accuracies. Some of these products are currently being generated for specific regions and are being made available to the public. However at this time there is no ongoing global fire data set production activity.

Research is being undertaken to enhance and compare algorithms for the current suite of sensing systems, develop product validation protocols, test algorithms with data from new sensors, prototype new algorithms for upcoming sensors, and evaluate algorithms using data from computer, laboratory and airborne simulations. Efforts are also underway to increase the availability of data through the World Wide Web and develop packages suitable for local to regional application by ground receiving stations. Examples of some of the recent development activities by researchers associated with the IGBP-DIS Fire Working Group are described below.

Researchers from the Hawaii Institute of Geophysics at the University of Hawaii have developed a hot spot monitoring web site using 4-km spatial resolution GOES-8 and GOES-10 data (http://volcano1.pgd.hawaii.edu/goes). Image data collected at the Naval Research Laboratory in Monterey, CA are forwarded to Hawaii where they are processed through a hot spot location algorithm using the difference of GOES Band 2 (3.8–4.0 μm) and 4 (10.2–11.2 μm). A set of six images including a map key showing hot spot locations, a 1-km GOES Band 1 (0.55–0.70 μm) cloud location image, and a 4-km resolution color image highlighting hot spots are displayed to the web site within 15 minutes of when the data are first received from the GOES satellite. Current study areas include a 500 km × 500 km section of Amazonia north of Cuiaba, Brazil, where fire duration and location for the current fire season are being tabulated, and a 500 km × 500 km area centered on Anaheim, CA, where Santa Ana wind-stoked fires in the Santa Barbara, CA area have been observed as late as October 19, 1998. The monitoring system has the capability to shift data collection to other study areas in the Americas within 24 hours of the receiving a report of particularly large and potentially persistent fires. While GOES coverage does not extend to the European and African continents, a similar real-time system could be envisioned to ingest geostationary sat-

Reference lists are available at http://web.mit.edu/igac/www/.

ellite data from Meteosat Second Generation-1 (MSG-1) planned for launch in the year 2000.

The Global Vegetation Monitoring unit of SAI/JRC and their collaborators are continuing research using low resolution satellite data for monitoring of active fires, burned surfaces, and vegetation status. Following the production of 21 months of the AVHRR Global Fire Product, the World Fire Web project that is currently in its pilot phase, is attempting to build an extensive vegetation fire monitoring network (http://www.mtv.sai.jrc.it/projects/fire/home.html). The pilot network consists of satellite receiving stations in Brazil, Italy, Vietnam, and Australia. During 1999, following commissioning tests on the software, the network will be expanded to include more stations. Plans have been prepared for Venezuela, Central African Republic, and Mongolia.

A multi-temporal burn-scar mapping algorithm currently under test will also be added to active fire detection and the fire maps will be made accessible to members of the network via the World Wide Web. Active fires and burned areas have been mapped as part of the EXPRESSO Campaign for the Central African Republic and are now being produced for the northern part of South America as part of the Amazon (LBA/CLAIRE) experiment. Work has also been completed on determining burned areas for the African continent for an eight-year period in the 1980s using AVHRR-GAC-4 km data. The accuarcy of applying the methods to determine global burned area from GAC data is being evaluated. Research has begun to determine vegetation moisture status to infer fire risk and burning efficiency from time series of AVHRR 1-km and SPOT VEGETATION data. The methods will initially be tested for West Africa and, if successful, they will be applied to other areas.

The NOAA National Geophysical Data Center (NGDC) in Boulder, Colorado archives data from the U.S. Air Force Defense Meteorological Satellite Program (DMSP). The suite of DMSP sensors includes the Operational Linescan System, which features a visible band which is intensified at night, permitting detection of city lights, fires, and gas flares. Most OLS data have a ground sample distance of 2.7 km. NGDC has developed algorithms to generate nightly fire products from the OLS data. This involves screening incoming data against a set of known light sources from cities, towns, and gas flares to identify ephemeral fire events. The thermal band on OLS is used for cloud detection and is at too long a wavelength for general use in fire detection. NGDC has completed a six-month global fire product for October 1, 1994 through March 31, 1995. Other project areas have included Madagascar (1992–97), Indonesia (1997), Mexico (1998), and the Amazon region (1998). Graphical products for many of these areas are available at http://www.ngdc.noaa.gov/dmsp/fires/globalfires.html. Compressed versions of the georeferenced fire and cloud images are made available through the NGDC ftp site. During the current fire monitoring of the Amazon region graphical products are being prepared for the individual Amazon states of Brazil. In this case the DMSP observed fire and cloud data are "stamped" onto forest/non-forest land cover maps derived primarily from Landsat TM data by the NASA Landsat Pathfinder project.

Researchers at ESA ESRIN have been developing a World Fire Atlas using AVHRR daytime data and Along Track Scanning Radiometer (ATSR) day and night time data. Three continents have been monitored for several years with AVHRR. The first continental atlas generated with ATSR data was for 1996. These data are readily available using the Fire Atlas Web Server (http://shark1.esrin.esa.it). An ATSR World Fire Atlas for 1997 is currently being generated and ATSR data will eventually be processed for 1995 to the present. Planning is underway to generate a global burned area product in mid-1999. ESA/ESRIN has also been examining the use of combined ATSR and Synthetic Aperture Radar (SAR) for the study of forest fires in Borneo. As part of their development program ESRIN has developed the capacity for an ATSR Rush Fire Product. This rush fire product could process 10 out of 14 orbits in near real-time permitting active fire maps to be on the World Wide Web in less than three hours from sensing for most of the world. This product could be used in supporting *in situ* validation campaigns.

The MODerate Resolution Imaging Spectroradiometer (MODIS) fire team is developing the scientific basis for remote sensing of fires and fire products (CO, CO_2, aerosols) using MODIS. MODIS is to be launched into a 10:30 AM orbit on Earth Observing System-AM (EOS-AM1) and into a 1:30 PM orbit on EOS PM (http://ltpwww.gsfc.nasa.gov/MODIS/MODIS.html). Each MODIS will have 3.9 μm and 11 μm channels with high saturation (450 K and 400 K, respectively) specially designed for fire monitoring. MODIS will have almost twice daily coverage. Its data will be used to detect fires, to estimate the rate of emission of radiative energy from the fire, and to estimate the fraction of biomass burned in the smoldering phase. The rate of emission of radiative energy is a measure of the rate of combustion of biomass in the fires. As a step towards inferring emitted gases from remote sensing of fire radiance, simultaneous measurements of fire infrared radiance and gas emissions for several different fuel types were made in a laboratory. These measurements correlate gaseous emission with radiant emission from biomass fires. If these correlations hold in the field, then satellite-observed infrared radiance can be used to estimate quantities such as total carbon burned, total biomass burned, and total carbon dioxide, carbon monoxide, and energy emitted from biomass fires on a global, daily basis.

In the Smoke, Clouds, and Radiation in Brazil (SCAR-B) experiment, the MODIS Airborne MAS was flown with a 50-m spatial resolution. These multispectral data were used to observe the thermal properties and sizes of fires in the cerrado grassland and Amazon forests of Brazil and to simulate and foresee the performance of the MODIS 1-km resolution fire observations. Although some fires saturated the MAS 3.9 μm channel, all the fires were well within the MODIS instrument saturation levels. Analysis of MAS data over four sites, representing different ecosystems, showed that the fire size varied from single MAS pixels (50 × 50 m) to over 1 km^2. The 1 × 1 km resolution MODIS instrument will observe only 30–40% of these fires, but the observed fires are mostly larger fires that are responsible for 80 to nearly 100% of the emitted radiative energy and therefore for 80 to 100% of the rate of biomass burning in the region. The rate of emission of radiative energy from the fires was found to correlate very well with the formation of the burn scar from the fire (correlation coefficient = 0.97). Therefore this new remotely-sensed quantity should be useful in regional estimates of biomass consumption when the two MODIS instruments are launched and in orbit.

The MODIS fire team is working with collaborators from the Southern Africa region and other NASA researchers to develop the SAFARI 2000 field experiment. In addition to a number of regional science objectives, this field experiment will be used to validate satellite-based fire and emissions data products. High spatial resolution satellite data, airborne imagery and field measurements will be used to validate MODIS data products. Field validation will be undertaken in conjunction with the IGBP Miombo Network (http://miombo.gecp.virginia.edu). A number of test sites have been selected and will be used for MODIS product validation (http://modarch.gsfc.nasa.gov/modis/land.val/).

Given the wide range of demands from the various user communities, the relatively small community of satellite fire researchers needs to adopt strategies that will satisfy critical and sometimes conflicting user demands. There is a need to balance the development of near real-time monitoring capability with the processing of archival data back to the beginning of the satellite record. There is a need to balance the development of new experimental algorithms with developing community consensus algorithms and processing systems for consistent distributed processing. There is a need to balance the generation and provision of new data sets, with documentation of the limitations and a clear statement of data set accuracy. Users are often unclear as to the utility of different data sets and their associated algorithms; algorithm and product inter-comparison studies can help clarify the pros and cons of different products. It is often easier to generate remotely sensed data products than it is to validate them quantitatively.

Although there has been a noticeable increase in fire product data availability, users remain frustrated at the lack of long term operational fire products. It often appears that the remote sensing community is proceeding to the latest sensing system without fully exploiting the utility of existing data archives and making time series data more widely available. This is in part due to the costs of data and large-volume processing, an awareness of the limitations of the existing systems, and the desire to provide improved products. In most cases the user community has relatively little insight into the state of various fire product development activities or where to obtain data. To this end NASA recently developed a satellite monitoring Web Site providing a summary of products that are available (http://modarch.gsfc.nasa.gov/fire_atlas/). This fire Web Site will transition into the Earth Observatory planned for the Earth Observing System.

The EXPeriment for Regional Sources and Sinks of Oxidants (EXPRESSO)

Contributed by **Robert Delmas**, *Laboratoire d'Aerologie, Toulouse, France and* **Alex Guenther**, *NCAR-ACD, Boulder, CO, USA*

EXPRESSO was an international and multidisciplinary program, conducted by European, American, and African scientists, to quantify and better understand the processes controlling surface fluxes of photochemical precursors along a tropical forest to savanna gradient in central Africa, and to evaluate and improve understanding of the production and loss of tropospheric oxidants within this region.

This experiment associated ground-based, aircraft, and remote sensing measurements, allowing investigation of surface fluxes of energy and trace gases from both savanna and forest ecosystems on one hand, and photochemical and dynamical processes in the lower atmosphere on the other hand.

The EXPRESSO domain extended from the savannas of the Central African Republic (CAR) in the north (8° N) to the tropical forests of the Republic of Congo (2° N) in the south. A research aircraft (the French Fokker 27-ARAT), instrumented for dynamics and chemistry measurements flew eleven missions out of Bangui, CAR, that covered a gradient from savanna to tropical forest. A 60-m walkup tower was installed at a nearly undisturbed tropical forest site. The tower provided access to the 45-m high canopy and the surface layer just above it. A detailed database of the extent of biomass burning in Central Africa during the EXPRESSO experiment was compiled using NOAA-AVHRR data (three acquisitions per day). In addition, a detailed vegetation map was built for the EXPRESSO region with an evaluation of net primary production per type of ecosystem based on long term records of NDVI data. Finally a landscape VOC emission potential database was developed based on NOAA-AVHRR data, ground surveys of vegetation type, and a vegetation emission rate database

Outline of the main results

The importance of the tropics on the chemical composition of the global atmosphere has been recognized for more than 15 years. The EXPRESSO field campaigns provide an original data set allowing description and better understanding of atmospheric chemistry in the northern African tropics. It complements the experiments conducted since the middle of the 1980s such as GTE/ABLE 2A (1985) and 2B (1987) in the Amazon, DECAFE (1998, 1991) and STARE/SAFARI (1992) in Africa. The results gained from EXPRESSO allow us not only to document and parameterize biogenic and biomass burning sources, but also to study exchange processes of energy and trace compounds in the region of the ITCZ. The main results can be summarized as follows:

1) The energy balance of savanna and forest ecosystems is primarily determined by evaporation (latent heat flux) with Bowen ratios of the order of 0.2 and 0.45 over forest and savanna respectively. The kinetic energy budget in the boundary layer is dominated by thermal (versus dynamic) production. This can be due to very weak horizontal winds in the vicinity of the intertropical converge zone (ITCZ), in spite of the strong roughness of both ecosystems. The location of the experimental domain, at the interface between savanna and forest ecosystems and in the middle of the ITCZ, results in a great complexity of dynamical fields. Vertical exchanges between the boundary layer and the free troposphere (monsoon and Harmattan flows) result from a diversity of processes occurring at various scales. They include (i) small scale processes such as entrainment, penetrative dry convection, waves and wave breaking, boundary layer clouds, and shear wind turbulence, (ii) mesocale processes such as organized cloud coverage, local divergence-convergence fields, penetrative cloudy convection and, (iii) synoptic scale processes linked to subsidence and ascendance.

2) A high density of fires was observed in savanna areas and, as a consequence, a high level of pollution was observed at regional scale. For instance regional concentration fields of CO and NO_y in the ranges 250–400 ppb and 4–10 ppb, respectively, and high concentrations of benzene (0.5 ppb) and black carbon (10 μg m^{-3}) illustrate the overwhelming influence of biomass burning on the chemical composition of the lower troposphere. Biomass burning occurs in savanna areas where the average number of fires detected every day in the "EXPRESSO window" is about 5000 with corresponding burned areas of 20,000 km^2/day. Aircraft data taken over the forest and ground based measurements taken at the forest site showed that biomass burning pollution widely contaminates the forest atmosphere. Biomass burning emissions were determined from (i) direct estimates of burned areas and above ground biomass density derived from remote sensing, and (ii) burning efficiency and emission factors. All these parameters present rather large uncertainties. To better constrain this dominant source, the redistribution of carbon monoxide, considered as an inert tracer of biomass burning, has been simulated using a 3-D non-hydrostatic mesoscale model coupled with an inert

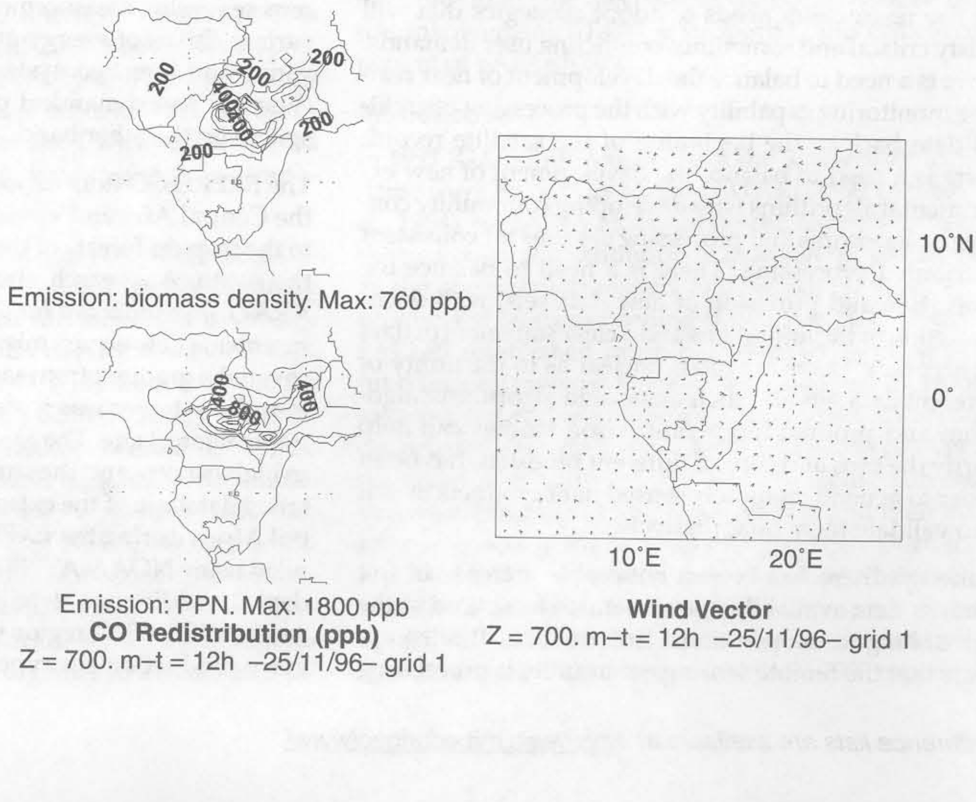

Figure 1. 3-D modeling of CO distribution in Central Africa, in the boundary layer (700 m altitude), on November 25, 1996, during the EXPRESSO campaign. The biomass burning source is estimated from (i) vegetation map and biomass density and (ii) from net primary production estimates retrieved from NDVI data and modeling (Cautenet *et al.*, 1998)

tracer emission module. The objective was to compare the CO distribution in the lower troposphere produced by the model with vertical profiles of CO concentration obtained from aircraft measurements, in order to assess the sensitivity to the magnitude and location of sources in redistribution of an inert tracer like CO and to constrain flux estimates. Estimated fluxes have to be divided by a factor of 2 to retrieve CO concentration fields consistent with aircraft observations; estimates of burned biomass in open fires is actually a difficult exercise.

3) Biogenic hydrocarbon emissions were investigated on a variety of scales along an ecological transect extending from the dry woodland savanna of northern CAR to moist tropical forest in the Congo. Above-canopy flux measurements at the forest site characterized diurnal and seasonal flux variations that were complemented by a regional spatial integration over the forest and the savanna provided by flux measurements using an airborne REA system. Mean isoprene fluxes observed with the aircraft system were approximately 1200 μg(C) m^{-2} h^{-1} over the forest and 500 μg(C) m^{-2} h^{-1} over the savanna. In comparison, isoprene fluxes measured with the tower based REA system over the forest ranged from nearly zero at night to over 1000 μg(C) m^{-2} h^{-1} in the middle of the day. Seasonal variations in isoprene fluxes observed at the tower site were greater than expected. A qualitative emission characterization was obtained for over 200 dominant vegetation species along the savanna to forest gradient and quantitative rates of the major biogenic VOC were estimated for about 60 plant species. Enclosure methods were also used to determine the relationships between emissions and environmental conditions. These data were used to develop a regional emission model which is in better agreement with the aircraft measurements than are previous estimates which were based on fluxes reported for a tropical forest in the Amazon basin.

4) Ozone and nitrogen oxide data allow study of photochemical characteristics of air masses in relation to ozone production efficiency (OPE). In the planetary boundary layer (PBL), high values of OPE are observed. Concentrations increase with photochemical age of the air mass so that OPE is lower in the Harmattan layer. To complement the ozone budget of the PBL, ozone fluxes were measured from the aircraft flying at low altitude over the savanna and the forest. Average deposition velocities are equal to 0.7 and 1.5 cm s^{-1} respectively on both ecosystems.

Conclusion

The results gained from EXPRESSO allow us not only to document and parameterize biogenic and biomass burning sources, but also to study exchange processes of energy and trace compounds in the region of the ITCZ. Because of experimental constraints linked to the capabilities of the aircraft used, investigations were limited to 4 km altitude; however model components can be evaluated using the experimental results. Based on the understanding gained from this work, improved submodels will be developed and implemented in regional and global scale chemistry and transport models. This modeling effort will help us better understand the chemistry of the upper tropical troposphere which is essential to assess the oxidation capacity of the global atmosphere. The tropical troposphere is strongly affected by cloud convection which favors fast vertical transfers of ozone precursors (CO, NMHCs, and NO, produced by the continental biosphere) within the rising branches of the Walker cells. These compounds drive O_3 production in the middle and upper troposphere. A significant impact on the stratosphere is also expected. Finally, in these regions, heterogeneous phase chemistry within convective clouds, assumed to be important, is almost unknown. Following EXPRESSO, future experimental projects in the tropics will focus on the impact of deep convection on the chemistry of the upper troposphere and lower stratosphere.

Domestic *versus* Wild Fires in Africa—A comparison between emissions from every-day domestic fire practices and wild fires

Contributed by **G. Helas and coworkers**, *Max Planck Institute for Chemistry, Biogeochemistry Department, Mainz, Germany*

Plant biomass provides about 14% of the world's demand of primary energy. Half of the global population covers an average of 35% of its energy needs by domestic biomass burning. In Africa, the biomass contribution alone to the total energy use typically ranges from 80–90% in poor, 55–65% in middle and 30–40% in high income groups. Unlike the occurrence of free-burning vegetation fires, which is usually restricted to several months during the dry season, domestic biofuel combustion takes place during the whole year.

To assess emissions from these domestic fire practices a few groups have investigated both consumption of biofuels and related emissions. Like the group of J.-P. Lacaux, Toulouse, France, we have studied patterns of biofuel use and made measurements of emissions of CO_2, CO, NO and occasionally organic compounds and aerosols in the lodgings of rural and urban Zimbabwe, Nigeria and Kenya.

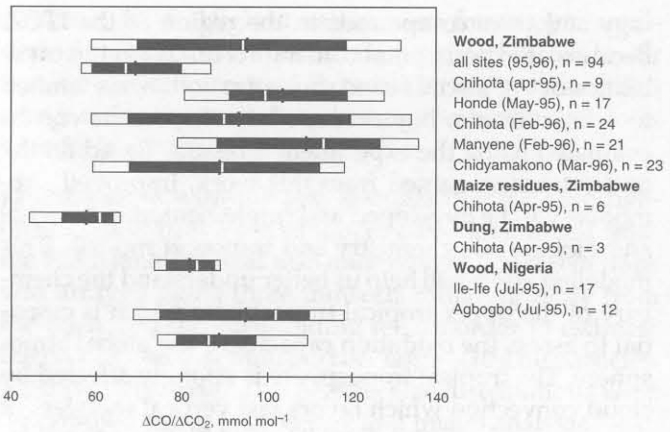

Figure 1. The statistical distribution of the time integrated ratios $\Delta CO/\Delta CO_2$ observed during domestic combustion of different biofuels at several locations in Zimbabwe and Nigeria.

Figures 1 and 2 show $\Delta CO/\Delta CO_2$ and $\Delta NO/\Delta CO_2$ ratios obtained in Zimbabwe and Nigeria during the field phases of 1995 and 1996 (Ludwig *et al.*, to be submitted). As the fuel mass consumed was determined as well, it was possible to quantify emissions from the domestic sources. Additionally, we collected information on biofuel consumption, which is compared to literature values in Table 1. We have to distinguish between urban and rural consumption rates as they differ considerably. Together with population statistics and the emission figures, we thus were able to assess the CO_2, CO, and NO emissions from domestic combustion processes. Results for Zimbabwe are compared to other sources in Table 2. It turns out, that for average fuel consumption rates CO_2 dominantly stems from domestic cooking practices, whereas for NO the emissions from soil and industrial processes are more important. We realize that such proportions of the different sources vary from region to region.

A tentative global analysis shows that the source strength of domestic biomass burning is on the order of 1500 Tg CO_2-C yr^{-1}, 140 Tg CO-C yr^{-1}, and 2.5 Tg NO-N yr^{-1}. This represents contributions of about 7 to 20% to the global budgets of these gases (Ludwig *et al.*, to be submitted).

Results of our work are published or are in the process of preparation for publication.

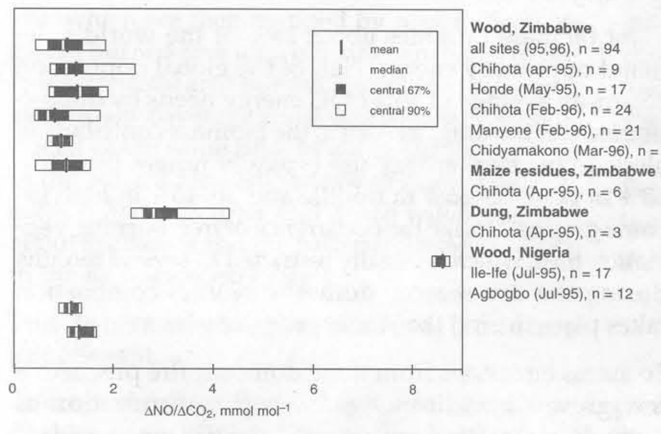

Figure 2. The statistical distribution of the time integrated ratios $\Delta NO/\Delta CO_2$ observed during domestic combustion of different biofuels at several locations in Zimbabwe and Nigeria.

Literature source	Fuelwood consumption rate estimates Mg capita^{-1} year^{-1} urban	rural
Hosier *et al.*, 1986	0.1	1.1
Attwell *et al.*, 1989	0.1	–
Grundy *et al.*, 1993		1.4
Campbell and Mangono, 1994	0.3	0.81
Hemstock and Hall, 1995	–	1.2
Marufu *et al.*, 1997a	0.56	0.95
Marufu *et al.*, b	0.4	1.3

[a] Marufu *et al.*, 1997 references can be found in (b)
[b] Maru fu *et al.*, to be submitted

Table 1. Fuelwood consumption rate estimates for Zimbabwe by different authors (taken from Marufu *et al.*, to be submitted).

Source	Emission CO_2 Tg C yr^{-1}	CO Tg C yr^{-1}	NO Tg C yr^{-1}
Domestic biomass burning	4.6	0.44	5.27
Savanna burning	2.0	0.11	8.9
Biogenic emission (soil)		–	22.2
Coal (industry)	3.8	0.001	21.6
Liquid fuels (transportation)	0.8	0.11	12.0

Table 2. Comparison of CO_2, CO, and NO emissions from different sources for Zimbabwe (taken from Marufu *et al.*, to be submitted).

Fire Research in the Boreal Zone of Eurasia and North America

Contributed by **B.J. Stocks**; *Canadian Forest Service,* **J.G. Goldammer**; *Max Planck Institute for Chemistry, Mainz, Germany;* **D.R. Cahoon**, *and* **W.R. Cofer**, *Atmospheric Sciences Division, NASA Langley Research Center, USA*

Introduction

The world's total boreal forests and other wooded land within the boreal zone cover 1.2 billion hectares (ha) of which 920 million ha are closed forest. The latter number corresponds to about 29% of the world's total forest area and to 73% of its coniferous forest area. The majority of the boreal forest lands (taiga) of Europe and Asia are located in Russia. The Russian Forest Fund comprises about 1,181 million ha out of which 1,111 million ha are under the control of the Federal Forest Service. The carbon stored in boreal ecosystems corresponds to around 37% of the total terrestrial global carbon pool (plant biomass and soil carbon). Thus, the magnitude of the boreal forest area suggests that it may play a critical role in the global climate system, e.g., as potential sink or source of atmospheric carbon.

Statistics compiled by the Russian Federal Forest Service show that between 17,000 and 33,000 forest fires, mainly human-caused, occur each year, affecting up to 2 million ha of forest and other land. Since fires are monitored (and controlled) only on protected forest and pasture lands, it is estimated that the real figures on areas affected by fire in Asia's boreal vegetation is much higher. Observations from satellites indicate that during the 1987 fire season approximately 14.5 million ha were burned (Cahoon *et al.*, 1994). In the same fire season about 1.3 million ha of forests were affected by fire in the montane-boreal forests of Northeast China, south of the Amur (Heilongjiang) River (Goldammer and Di, 1990).

Forest fire is also the dominant disturbance regime in Canadian boreal forests, and is the primary process organizing the physical and biological attributes of the boreal biome, creating an ecosystem largely dependent on periodic fire for its existence. Canada has 418 million hectares of forested land, 218 million hectares of which are capable of producing commercial forest products. In Canada, over the past two decades, an average of ~9000 fires have occurred yearly, burning an average of ~2.8 million hectares annually, although annual area burned is highly episodic, and has varied by an order of magnitude (e.g., 0.67 million hectares in 1997, 7.28 million hectares in 1995). Large areas of northern Canada, primarily non-commercial forest, receive a modified form of fire management, where fires are allowed to burn naturally unless they threaten commercially valuable stock; this fire management policy contributes significantly to the large areas burned in the boreal regions of Canada (Stocks *et al.*, 1996).

The Fire Research Campaign Asia-North (FIRESCAN)

The *Fire Research Campaign Asia-North* (FIRESCAN) was initiated in 1992. FIRESCAN addresses the role of fire in boreal ecosystems and the consequences for the global atmosphere and climate. On 6 July 1993 a large forest fire experiment was conducted on Bor Forest Island, Krasnoyarsk Region, Russia. The major objective of the Bor Forest Island Fire Experiment was to conduct a high-intensity, stand replacement fire that would permit the documentation of fire behavior and effects in a manner that would allow comparison of eastern and western fire research methodologies. The major parameters investigated comprised:

1) Fire ecology of *Pinus sylvestris* forests of the Sym Plain, including the long-term pollen and sediment records and a dendrochronology-derived fire history
2) Vegetation and fuels (pre-fire and post-fire recovery, fuel loading and consumption, tree mortality)
3) Fire behavior (fuels, fire weather, fire behavior)
4) Emissions of gases (CO_2, CO, H_2, CH_3Br, CH_3Cl) and aerosol (particle deposition)

A high-volume sampling system was installed on an Aeroflot MI-8 helicopter and used to collect smoke samples immediately above the Bor Forest Island Fire. Particle-filtered samples were drawn through a probe mounted on the nose of the helicopter. This probe was coupled to a high-volume pump inside the helicopter by flexible hose. In thirteen smoke sampling runs three fire stages were analyzed: flaming combustion during the surface fire phase (F1), flaming combustion during the high-intensity crowning phase (F2), and smoldering phase (S3). Of major interest is the fact that samples collected during the high-intensity phase (F2) of the Bor Island Fire revealed elevated carbon monoxide emission ratios, suggesting lower combustion efficiency than previously inferred from results obtained from Canadian boreal logging slash fires during flaming combustion (Cofer *et al.*, 1990). Methane and hydrogen emission ratios, however, were similar to measurements obtained in the Canadian fires. During the smoldering combustion phase (S3) carbon monoxide emission ratios were almost three times higher than on Canadian logging slash fires.

To complement the NASA trace gas emissions measurements, both helicopter and ground-based grab sampling (using stainless steel vacuum canisters) of emissions for specific analysis of methyl bromide (CH_3Br) and methyl chloride (CH_3Cl) was also carried out during the Bor Forest Island Fire. The emission ratios of CH_3Br and CH_3Cl measured in the Bor Forest Island Fire were in the range of $1.1–31 \times 10^{-7}$ and $0.2–12 \times 10^{-5}$, respectively. This was considerably higher than those found in savanna and chaparral fires or in laboratory experiments (Manö and

Reference lists are available at http://web.mit.edu/igac/www/.

Andreae, 1994). Highest values were found over smoldering surface fuels. This can be explained by the lower combustion efficiency of the smoldering process when compared to the prevailing flaming combustion of grass-type fuels.

In connection with the lake sediment coring investigation, a study of the dispersion of particles emitted from the Bor Island Fire was also undertaken. A series of traps was arrayed along three transects radiating away from the burn into the surrounding fen, in order to estimate the production and transport of "large" (10 µm) particles. Total particle fluxes and particle size distributions were determined using microscopy and image analysis.

The complete results of the experiment are published in the pages of FIRESCAN (1996) and Cofer *et al.* (1996).

Satellite data archive evaluation

NOAA AVHRR imagery is being used to map burned areas in the Russian boreal forest. The use of the AVHRR imagery can provide a continuous and consistent record of burned area each year and provides a basis for modeling carbon cycling in the boreal forest. The NOAA AVHRR instrument has been in operation since 1979. Since that time, there is an almost continuous archive of mid-afternoon imagery. Despite its poor resolution (~4-km nadir), this imagery has been demonstrated to be very suitable for monitoring boreal fire activity. The reason that the 4-km imagery is suitable for mapping fires in the boreal forest is that most of the area burned is by the larger fires that are easily detectable. We have collected imagery that spans the decade of the 1980s and we have begun to analyze the imagery to map the area burned each year. The mapping of the burned area is a multi-step process that begins with the radiometric correction of each scene. Each corrected scene is classified to reveal the burned areas, which are then mapped by region. Each regional burned area map is further analyzed to calculate the total area burned. Other products, such as clear-sky coverage and active fire maps are produced at the same time to aid in the assessment of the burned area estimates and burned area locations. We anticipate that much will be learned about fire trends and fire patterns during the 1980s in the Russian boreal forest.

The International Crown Fire Modeling Experiment

Conceived following the Bor Forest Island Fire Experiment in central Siberia, the *International Crown Fire Modeling Experiment* (ICFME) has been underway in the Northwest Territories of Canada over the past four years. The ICFME is being conducted under the auspices of the Fire Working Group of the International Boreal Forest Research Association (IBFRA), established in 1992 to foster cooperative research into the role of fire in northern circumpolar boreal forests (Fosberg, 1992).

Wildland fire research scientists in Canada and the United States had worked independently for many decades on the development of fire danger rating and fire behavior prediction systems which are currently in widespread use across North America and overseas. Although these systems are considered the best in the world, the development of a predictive physical model that could encompass the full range of fire behavior encountered in nature had proven an elusive goal for both Canadian and American fire scientists, and by the early 1990s, they began increasing their collaborative research activities in this area. At the same time, after decades of isolation caused by the Cold War, western and Russian fire scientists began meeting to discuss research methodologies and the possibility of working collaboratively. The first product of this new initiative was the Bor Forest Island Fire Experiment, but additional joint investigations were also developed, including the remote sensing of boreal fires, fire danger rating, fire behavior modeling, and climate change/forest fire/carbon budget impacts research. Clearly, for a number of converging reasons, the timing was opportune for the development of a large-scale international investigation of high-intensity fire behavior, and the ICFME was born.

Figure 1. Typical high-intensity boreal crown fire behavior during the 1998 phase of the International Crown Fire Modeling Experiment in Canada's Northwest territories.

The ICFME study area is located 40 km northeast of Fort Providence in Canada's Northwest Territories (61.6° N x 117.2° W), in a dense 65-year-old stand of jack pine (*Pinus banksiana Lamb.*), 12 m in height, with a black spruce (*Picea mariana (Mill.) BSP*) understory—a fuel complex ideally suited to the generation of high-intensity crown fires. A series of ten burning plots, the majority averaging 2.25 ha in size (150 × 150 m), were located at this site in 1995. After extensive preburn sampling in 1996, five experimental crown fires were conducted during the 1997–98 period, three in July 1997 and two in July 1998. All fires exhibited typical boreal forest high-intensity crown fire behavior: spread rates of 2–3 km/hr, fuel consumption levels of 40–50 tonnes/ha, flame heights ~30m, and energy release rates of 35,000-70,000 kW/m. These fires are the most complex, heavily instrumented experimental crown fires ever conducted. Ground-, tower-, and aircraft-based instrumentation, including continuous video, was used to measure, among other things, in-stand and above-stand radiation fluxes, vertical temperature profiles, spread rates, fuel consumption, fire residence times, and trace gas/aerosol emissions.

While the initial impetus for ICFME was the development of a physical model of the initiation and propagation of crown fires, this experiment has provided the opportunity to examine other aspects of the implications of crown fire behavior, including linkages to firefighter safety and wildland-urban interface concerns. Heavily instrumented fire shelters and housing structures have been tested on the ICFME crown fires to develop new protection standards for both firefighters and communities. Over the past two years, seven new burning plots were established to address these issues.

While the ICFME primary participating agencies are the Canadian Forest Service, the United States Forest Service, and the Government of the Northwest Territories, the list of additional collaborators actively participating in ICFME is growing. This group currently includes the Russian Forest Service, the National Aeronautics and Space Administration, the Government of Alberta, the Max Planck Institute for Chemistry, the National Institute of Standards and Technology, Storm King Mountain Technologies, Duke University, Montana State University, and the University of Alberta. The ICFME has also attracted media attention, including film/video companies from England and Austria.

Further experimental fires are planned for 1999 and beyond. Data exchange workshops are planned, and ICFME science results will be published in a dedicated volume within the next few years. Two overview/progress reports have been produced (Alexander *et al.* 1998a; Alexander *et al.* 1998b). In addition, a dedicated ICFME web site has been established (http://www.nofc.forestry.ca/fire/fmn/nwt/) that includes daily updates during the field program along with background and progress reports.

A third IBFRA/IGAC/BIBEX experimental boreal fire initiative is FROSTFIRE, a 1999 experiment involving a watershed burn (800 hectares) near Fairbanks, Alaska, designed to investigate fire/climate/permafrost/hydrology interactions (see http://www.fsl.orst.edu/home/usfs/gepp/alaska/frstfire.htm).

The *Global Fire Monitoring Center* (GFMC) and IGAC-BIBEX

Contributed by **Dr. Johann G. Goldammer**, *Max Planck Institute for Chemistry, Mainz, Germany*

The state of fire science (fundamental fire research, fire ecology) in most vegetation types, and the results of biogeochemical and atmospheric science research of the last decade provide sufficient knowledge for supporting decision making at fire policy and management levels. However, it is evident that in many countries of the developing world the state of scientific and technical information is neither known nor readily accessible for developing adequate measures in fire policies and management. The fire and smoke episode of 1997–98 in South-East Asia was a good example that existing fire information systems or fire management expertise was utilized only to a limited extent. These circumstances led to confusion at national and international decision-making levels and led to delayed response by a series of national and international entities, some of them even missing the targets. This can be explained by the lack of an information system which is accessible globally. An information and monitoring system was needed which national and international agencies involved in land-use planning, disaster management, or in other fire-related tasks can utilize for planning and decision making.

In June 1998 the Global Fire Monitoring Center (GFMC) was established at the Max Planck Institute for Chemistry (Germany). Following the principles which were developed for a scientific Global Vegetation Fire Information System at the Dahlem Conference "Fire in the Environment" in 1992, the Global Fire Monitoring Center in its first phase will document archived and provide real-time or near-real time information related to fire. This will include interlinking with other national, regional, and international information systems. In the second phase the GFMC will integrate global fire inventory data with fire emissions research data.

For its first phase the GMFC is sponsored by the government of Germany, Ministry of Foreign Affairs, as a German contribution to the UN International Decade for Natural Disaster Reduction (IDNDR). The fire documentation, information and monitoring system is accessible through the Internet at http://www.uni-freiburg.de/fireglobe.

BIBEX is among the co-sponsors of the GFMC. The BIBEX homepage is linked to the GFMC website but can also be visited directly at the Max Planck Institute's server: http://www.mpch-mainz.mpg.de/~bibex

The GFMC supports international organizations (UN and non-UN) in developing strategic plans and programs to address fire and fire-generated problems such as effects of pyrogenic smoke on human health. These programs and a large number of national and international projects are all included in the GFMC homepage.

SAFARI-2000: A Southern African Regional Science Initiative

Contributed by **Bob Swap**, *University of Virginia;* **Harold Annegarn**, *Univeristy of Witwaterstrand, South Africa;* **Mary Scholes**, *Univeristy of Witwaterstrand, South Africa;* *and* **Chris Justice**, *University of Virginia*

Abstract

SAFARI-2000, currently in its planning phase, is an international, collaborative science initiative whose purpose is to understand the operation of the southern African biogeophysical system as an integrated, interconnected system. Key linkages between physical, chemical, biological, and anthropogenic processes essential to the functioning of the biogeophysical system will be examined. SAFARI-2000 includes the following science components: terrestrial ecosystems and biogeochemical modeling; land-cover and land-use change mapping, monitoring, and modeling; fire disturbance studies; quantification and modeling of pyrogenic, biogenic, and industrial emissions and their transport; aerosol and cloud characterization and their interactions; atmospheric chemistry and modeling, and atmospheric deposition studies. Of particular interest to the IGAC community is the SAFARI-2000 focus on aerosols and trace gases, especially with respect to sources, transformations, patterns, responses, and processes.

SAFARI 2000 follows on the success and builds upon the scientific legacy of SAFARI-92. SAFARI-92 focused on developing the fundamental understanding of biomass burning processes in a subtropical savanna, but stopped short of fully exploring the consequences of these processes. More importantly, perhaps, SAFARI-92 established a basis for international collaboration among scientists working across many different disciplines. It is on this foundation that SAFARI-2000 is being developed. SAFARI 2000 will take the next step and apply findings to determine many of the consequences of biomass burning and other processes associated with regional land cover and land use changes to the ecosystems of southern Africa.

The initial motivation for a post-SAFARI-92 research initiative originated with a number of regional planning meetings and documents that identified global change science priorities for the Southern African Region (e.g., IGBP Report 31, IGBP Report 41, IGBP Report 42 and the START Regional Workshop on Global Changes, Gaborone, 1994; IGBP Miombo Workshop, Lusaka, 1997). SAFARI-2000 emerged as a tractable regional science initiative during a series of stakeholder workshops held during June and July 1998. At a U.S. NSF-sponsored workshop on Southern African Land/Atmosphere/Biosphere Interactions, that was held on July 11–17, 1998, in Blydpoort, Mpumalanga, South Africa, some 70 participants from twelve countries came together to discuss and develop SAFARI-2000. Much like its predecessor, the IGAC/BIBEX-SAFARI-92 program, SAFARI-2000 is a confederation of affiliated national, regional, and global environmental change research efforts that are currently underway or will be undertaken soon in the southern African region. NASA, through its EOS, Land Cover and Land Use Change, and Terrestrial Ecology Programs is supporting a number of ongoing research efforts within the southern African region that will contribute to SAFARI-2000.

Additionally, a strong satellite data product validation component associated with the launch of NASA's Earth Observing System (EOS) AM-1 platform in 1999 and other new sensing systems will be undertaken in the context of these science activities. Validated remotely sensed data products will be provided as inputs to the above studies.

SAFARI-2000 will be conducted over a three-year period starting in the second half of 1999 with major field campaigns during 1999 and 2000. SAFARI-2000 will utilize field sites that are representative of major regional land cover variants, have a scientific heritage and that are subjected to long-term preservation. The two key sites are Mongu, Western Province, Zambia and Skukuza, Kruger National Park, South Africa. Based on lessons learned from previous regional field campaigns, post-field campaign data integration is actively being planned. A synthesis of results will be available in 2001. SAFARI-2000 will add scientific value by enabling the synthesis and coordination between these different activities within the region, providing a basis for budget closure experiments and a contribution to a regional science assessment of global change. The international regional science networks, developed over the years within the region through IGBP and START, will participate in the initiative, providing the mechanism for broad African scientific involvement. START is supporting this critical component of SAFARI-2000.

Introduction

In 1992 IGAC-BIBEX undertook the *Southern Africa Fire-Atmosphere Research Initiative* (SAFARI) 1992 (Andreae *et al.*, 1994). SAFARI-92 focused on the factors controlling the process and distribution of biomass burning as well as the chemistry, transport and source strength of the products of biomass burning (Lindesay *et al.*, 1996). SAFARI-92 established much of the understanding of the fundamental biomass burning processes in a subtropical savanna, but was only minimally dedicated to the consequences of these processes. SAFARI-92 involved over 150 scientists from fourteen countries and focused on observations related to African savanna fires and their atmospheric effects in the southern hemisphere. During SAFARI several partnerships were developed between international scientists studying land-atmosphere interactions. The continued development of these relationships has culminated in the proposed SAFARI-2000 experiment.

SAFARI was chosen as a rallying acronym for the initiative, centered on the millennium and with a heritage of international collaboration within the region. The project initiated by a core group of collaborating scientists has received preliminary endorsement from the IGAC BIBEX group. SAFARI 2000 will follow the model of the SCAR-B (Smoke Cloud Aerosol and Radiation) experiment (Kaufman *et al.*, 1998) also undertaken in the BIBEX framework, combining satellite, aircraft and in situ experiments but with stronger terrestrial ecosystems, land cover and land use change,and satellite validation components.

Central and southern Africa have undergone and continue to undergo large changes in social, economic, and political environments that contribute to large-scale changes in land use and land cover within their respective ecosystems. The opening up of southern Africa due to the absence of war and political strife has led to economic development, especially in the sector of heavy industry. Energy generation to drive mining and metallurgical industries, as well as the industrial processes themselves, contribute to high levels of aerosol and trace gas emissions (Held *et al.*, 1996; Siversten *et al.*, 1995). Additionally, this region of Africa is subjected to some of the most extensive biomass burning in the world, most of which is associated with human population pressures on regional ecosystems (Crutzen and Andreae, 1990; Helas and Pienaar, 1996; Scholes *et al.*, 1996; Justice *et al.*, 1996). These anthropogenic perturbations, along with a strong source of biogenic emissions (Harris *et al.*, 1996; Parsons *et al.*, 1996; Levine *et al.*, 1996; Guenther *et al.*, 1996) and a large natural variability in both regional climate and ecosystem processes combine, primarily through manipulation of surface aerosol and trace gas emissions, to effect changes in the biogeochemical cycling of the region.

Much progress has been made recently through international scientific research concerning changes in land cover and land usage, atmospheric circulation and transport, biogeochemistry, and ecosystem functioning in southern and central Africa. The implementation of the IGBP Terrestrial Transects program (Koch *et al.*, 1995), the creation of the IGBP Miombo network (Desanker *et al.*, 1997) and the IGBP LUCC/DIS/START Miombo CD-ROM, the IGBP Kalahari Transect (Scholes and Parsons, 1997), the IGBP BIBEX (*Biomass Burning Experiment*) SAFARI/TRACE-A field campaigns (Andreae *et al.*, 1994; Lindesay *et al.*, 1996; Fishman *et al.*, 1996), the formation of the *Southern African Atmospheric Research Initiative* (SAARI) alliance as well as the involvement of IGAC's *Biosphere-Atmosphere Trace Gas Exchange in the Tropics* (BATGE; Guenther *et al.*, 1995, 1996) and *Deposition of Biogeochemically Important Trace Species* (DEBITS) Activities within the region, are all examples of such progress within the IGBP.

Although these projects have all contributed to the understanding of discipline-specific objectives, exploration of linkages between and the integration of information from each of the programs to form a more complete and interdisciplinary understanding of the functioning of southern and central African ecosystems and the regional atmosphere has been given less attention. It is envisaged that by international collaboration through SAFARI 2000, new *in situ* data collection combined with advances in the modeling of the bio-geophysical systems and improvements in satellite monitoring will lead to an improved understanding of regional and global environmental change in southern Africa.

Research Objectives

The goal of SAFARI 2000 is to understand the key linkages between the physical, chemical and biological processes, including human impacts, essential to the functioning of the southern African biogeophysical system. Broadly, SAFARI-2000 aims to: characterize and quantify the biogenic, pyrogenic and anthropogenic aerosol and trace gas sources and sinks in southern Africa; validate these observations using atmospheric transport and chemistry models, ground-based, air-borne, and satellite-based observations; and determine the climatic, hydrological, and ecosystem consequences of these biogeochemical processes. Specific questions about aerosols and trace gases were developed at the Blydepoort workshop with the following scientific progression in mind: sources; transformations; patterns; responses; and interactive processes.

To this end, SAFARI 2000 will exploit current and planned regional remote sensing, modeling, airborne and ground-based environmental studies, as well as combine the expertise and knowledge base of regional and international scientists. This will involve the use of models that integrate *in situ* observations of ecosystem processes such as biophysical energy and water exchanges with the atmosphere, biogeochemical cycling, and plant demographics. The observations and modeling will extend across spatial scales from plot to landscape and region scales and across time scales from hours to weeks to years. Important components of the SAFARI 2000 objectives are model and satellite product evaluation by local experts, as well as the promotion of informed use of these models and data by regional scientists. Special attention is being given to data access and timeliness of data availability. Information from SAFARI 2000 activities will be disseminated regionally and internationally via the internet as well as through the distribution of CD-ROMs. IGBP-DIS will assist in facilitating the access to and management of the data associated with this regional research initiative.

Science Rationale for the Initiative

Southern Africa, targeted as an Inter-governmental Panel for Climate Change (IPCC) science assessment focus re-

Reference lists are available at http://web.mit.edu/igac/www/.

gion, is an area where global change, in the form of increasing population and population migration, industrial development, vulnerability of rain-fed subsistence agriculture, poor economic resilience, water and food availability, and trans-boundary developmental issues, is very likely to have a large impact on the biogeophysical functioning of the region. Results of the SAFARI-92 and SA'ARI-94 (see TRACE-A and SAFARI Special Issue, JGR, 101(D19), 1996; Helas *et al.*, 1995) field campaigns have led to the formulation of questions, many of which are unanswered, that require a more synthetic, integrated and interdisciplinary research.

With respect to the tractability of the proposed research, the atmospheric environment, with clearly defined inflow and outflow regions, and the geography of Africa south of the Equator permit a reasonably discrete study region, which in turn permits mass-balance calculations to be performed. The semi-closed atmospheric circulation provides both a context and integrating mechanism between the living and physical systems. This is especially the case during austral winter when anticyclonic circulation and associated clear sky conditions favorable for satellite and airborne remote sensing, dominate the region on as many as four out of every five days (Garstang *et al.*, 1996; Tyson *et al.*, 1996). It will be possible to conduct a closed experiment within southern African that is focused on the characterization of biogeochemical and biogeophysical in-flow and outflows to the region. The existing regional scientific database, when combined with the regional scientific and logistic base, provides the framework necessary for conducting SAFARI-2000.

Way Forward and Next Steps

Numerous government and scientific agencies from the U.S., Europe and Southern Africa have been briefed on the development of SAFARI-2000. The science plan is currently being developed and should be ready for wide distribution early in 1999. SAFARI 2000 will be conducted over a three-year period starting in 1999 with both intensive ground and flying field campaigns during 1999 and 2000. Three intensive flying campaigns, with each successive campaign increasing in the level of international collaboration, are scheduled: August–September 1999: dry season, biomass burning campaign; February–March, 2000: wet season campaign; August–September 2000: dry season biomass burning campaign. Intensive ground-based efforts will also be coordinated to maximize overlap in the observations. The whole campaign will be supported by intensive meteorological measurements.

The SAFARI 2000 initiative is open to international participation to help achieve its regional research objectives. For further information on SAFARI 2000 contact http://safari.gecp.virginia.edu.

IGACtivities Past and Future

Many readers of this newsletter probably do not know that the notion to have an "IGAC newsletter" arose during the initial planning for IGAC a decade ago. It's right there on pages 36–37 of the 1989 "Dookie Report" which described the original structure and implementation plans for IGAC. By early 1995 sufficient resources became available to the Core Project Office to produce a periodic newsletter. Former IGAC-SSC Chair, Ron Prinn and I then had to decide what its nature should be. Other scientific project newsletters we had seen covered a wide spectrum in terms of content and presentation. At one end were those consisting almost entirely of meeting reports and announcements, news about people, and so forth, with only occasional tidbits of science, in a photocopy-and-staple format. At the other end were glossy, magazine-quality newsletters full of well-written summaries of scientific results and progress. We decided to get as close to this latter model as we could.

Looking back at early issues, I do not think that we did too well at the beginning. However, I hope that most readers will agree with me and current SSC Chair, Guy Brasseur that more recent issues—especially the ones produced this past year—are more substantive (and not just longer!). But what really matters is what you, the readers, think.

Please take a few minutes to communicate your opinions of the IGAC*tivities* newsletter to us (IGAC Core Project Office, MIT, Bldg. 24-409, Cambridge, MA 02139-4307, USA; Email: igac@mit.edu; Fax: +1-617-253-9886). Should we continue to produce it or not? If not, then why not? If so, then what would you like to see or not see in future issues to make them more interesting, useful, or maybe even *exciting* occasionally? Would *you* like to contribute a science feature?

Thanks very much for your time.

—Alex Pszenny, IGAC Core Project Officer

BIBEX in the Future

A major reorganization of the BIBEX Coordinating Committee which had been discussed since early 1998 was unanimously agreed at the last meeting which was held in conjunction with the joint CACGP/IGAC conference in Seattle (19–25 August 1998). As the new Conveners of BIBEX we wish to pay tribute to Meinrat O. Andreae—better known as "Andi"—for his decisive leadership of BIBEX during the ten years since it was founded in 1988.

Andi graduated from Göttingen University (Germany) and received his PhD in 1978 at UC San Diego. After holding the position of professor of oceanography at Florida State University between 1978 and 1987 he moved to Mainz (Germany) where he has been serving as Director of the Biogeochemistry Department of Max Planck Institute for Chemistry. He is also professor in the Environmental Engineering Science Department at the California Institute of Technology (Caltech). One of his main scientific interests is in the role of fire in atmospheric chemistry and biogeochemical cycles. The research groups in the Biogeochemistry Department are all fully or partially involved in fire research.

One of Andi's visions was the clarification of the role of vegetation fires in the global environment through interdisciplinary research programs open to the international science community. We all thank Andi for his energetic contributions.

The new list of BIBEX committee members can be found on the BIBEX homepage (http://www.mpch-mainz.mpg.de/~bibex). On behalf of the whole BIBEX community we wish to thank all former Committee members for their long-lasting involvement.

Given the progress of research achieved during the lifetime of BIBEX in biomass burning emissions, chemistry, and related atmospheric chemistry processes, the Committee agreed that the future focus of BIBEX should give special attention to regional and global inventories (including remote sensing of fires), fire ecology, and global fire modeling.

At one panel discussion during the CACGP/IGAC conference in Seattle relationships between the science community, policy makers, and the public were discussed and deficiencies identified. Being challenged by the recent public debates on fire and smoke in Southeast Asia, Latin America, and the Far East of Russia, the BIBEX community feels encouraged to continue close cooperation with international organizations and agencies to facilitate development of national, regional, and global strategies and policies addressing fire.

The recent consultation of the Food and Agriculture Organization of the United Nations (FAO) on "Public Policies Affecting Forest Fires" (Rome, 28–30 October 1998) and the endeavours of the World Health Organization (WHO) in developing the "WHO Health Guidelines in Episodic Vegetation Fire Events" (Lima, 6–9 October 1998) both requested inputs from the fire science community. The overall goals of the UN programs, which include the role of the UNEP and the WMO, are targeted towards development of policies which will contribute to reducing the negative impacts of wildfires and land-use fires on human health and safety, environment, and sustainable development. The human dimension of fire challenges us to cooperate more closely cooperation with the social and political sciences.

More than ever before we feel that BIBEX is an important activity within the IGBP to understand the role of vegetation burning in past, current and future global change processes. With an improved information and monitoring system on global fire—the Global Fire Monitoring Center—we anticipate greater interaction with the community through exchange and processing of information, and the further development of a science agenda.

—Johann G. Goldammer and Joyce E. Penner
Mainz/Freiburg and Ann Arbor, 8 November 1998

Announcements

First International Workshop on Long Term Changes and Trends in the Atmosphere (LT-ACT'99)

Pune, India • 16–19 February 1999

This Workshop will bring together various groups of experimentalists and modelers to improve our understanding on the long term variations and trends in the middle and upper atmosphere (10 to 120 km). Results from the past several decades of observations and future predictions (using interactive models) will be the major focus. The Workshop will address the following questions:

- What long term changes have been observed and will be able to be studied in the near future ?
- What are the explanations of the variability and trends in terms of known physical, chemical, and dynamical processes ?
- Which tropospheric processes can be identified as causes for middle atmospheric long term changes and which middle atmospheric phenomena or observations can be used to identify/monitor long term changes in the lower atmosphere ?

Specific broad topics include:

- Availability of data sets (ground based, satellite & rocket measurements) and their trend analysis.
- Global change (anthropogenic or other) and changing neutral composition, ion chemistry, aerosol abundance, thermal structure and dynamics (winds, IGW-intensity, planetary wave activity and meteorological activities).
- Model results and predictions for the future decades.
- Interpretation of the changes in terms of known physical, chemical, and dynamical processes.
- Identification of the role of natural (solar, volcanic, meteorological origin) versus anthropogenic changes.

Note: Due to satellite communication problems in India, please send all correspondence to:

beig@acd.ucar.edu
Fax: 1+303-497-1400 (USA)
WEB site: http://acd.ucar.edu/~beig/iitm.html
or contact: Dr Gufran Beig
Indian Institute of Tropical Meteorology
Pashan, Pune, 411008, India.
Tel: +91-212-330846
Fax: +91-212-347825.

International Scientific Program Committee (SPC):

Jan Lastovicka (Czech Republic); G. E. Thomas (USA); M.-L. Chanin (France); V. Ramaswamy (USA); T. Tsuda (Japan); Guy Brasseur (USA); A.P. Mitra (India) ; Karin Labitzke (Germany); E. S. Kazimirovsky (Russia); Adolf Ebel (Germany); Lon Hood (USA); A. D. Danilov (Russia); Gufran Beig (India)-Convener/Scientific Secretary

International Workshop on the Atmospheric N_2O Budget: An analysis of the state of our understanding of sources and sinks of atmospheric N_2O

Tsukuba, Japan • 23–25 March 1999

Sponsors: Environment Agency of Japan, US-NSF, and US-NASA.

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Analyses of potential and known sources of atmospheric N_2O suggest that our understanding of sources and sinks of atmospheric N_2O may not be as complete as recently thought. The potential for photochemical production of N_2O directly in the atmosphere has been demonstrated theoretically and under laboratory conditions; and using the 1996 IPCC National Inventory Methodology guidelines for estimating N_2O from agricultural systems indicates that the terrestrial anthropogenic sources of N_2O had previously been underestimated. If the analyses of the atmospheric burden of N_2O, atmospheric lifetime, and stratospheric exchange are correct, then the atmospheric sources and sinks of N_2O are not well characterized and the current budget estimates are not correct. The analysis of stable isotopes of both N and O in N_2O may potentially help resolve this uncertainty and a thorough investigation of the isotopic composition of known sources and sinks and how mixing ratios of these isotopes interact and change over time is needed. The purpose of this workshop is to bring together researchers from atmospheric, aquatic, and soil sciences and experts in isotopic analyses and interpretation to discuss and report the current understanding of sources and sinks of atmospheric N_2O. The program will consist of lectures from fifteen invited speakers from the areas of atmospheric chemistry, oceanography, and soil science and selected volunteered oral papers, poster sessions, and a roundtable discussion session.

Abstracts should be submitted to H. Tsuruta before 15 February 1999.

EGS XXIV General Assembly

The Hague, The Netherlands • 19–23 April 1999

Session OA24: Tropospheric aerosols: Formation and Heterogeneous Chemistry

Heterogeneous or multiphase processes on solids or in liquids may be central in determining the composition of the troposphere (as for example for cloud chemistry) and therefore should be included in models. But their effects cannot be assessed accurately because of a lack of information on the nature (formation processes and composition) of the condensed matter or of its reactivity (uptake of trace gases, initiation of new reactions). Therefore the aim of this symposium is to discuss recent advances of our knowledge of tropospheric heterogeneous processes especially centered on the microphysics and heterogeneous reactions of tropospheric particles. Accordingly, we invite contributions in the following areas:

Organic aerosols: formation from hydrocarbon oxidation (natural and anthropogenic HCs);
Co-convener: T. Hoffmann
Sulfate aerosols: formation from sulfur oxidation;
Co-convener: H. Berresheim
Heterogeneous chemistry on sea salt aerosols;
Co-convener: J. Crowley
Heterogeneous chemistry on carbonaceous aerosols;
Co-convener: M. Ammann

These different themes will bring together scientists from different discipline in an effort to focus resources onto these important problems in atmospheric chemistry.

Deadline for Receipt of Abstracts: 15 December 1997

Send abstracts to:
EGS Office
Postfach 49
D-37189 Katlenburg-Lindau, Germany
Fax: +49-5556-4709,
e-mail: egs@linax2.dnet.gwdg.de

Please do not forget to send a copy to one of the conveners!

More general information:
EGS Office
Tel: +49-5556 1440
Fax: +49-5556 4709
egs@copernicus.org
http://www.copernicus.org/EGS/egsga/denhaag99/denhaag99.htm

Second International Symposium on Non-CO_2 Greenhouse Gases (NCGG-2) Scientific understanding, control and implementation

Noordwijkerhout, The Netherlands • 8–10 September 1999

In support of the IPCC-process

Organised by: Dutch Association of Environmental Professionals -VVM

Section for Clean Air in The Netherlands (CLAN)

Introduction

In 1993 the Society for Clean Air in The Netherlands, presently working as the Clean Air section of the Dutch Association of Environmental Professionals (VVM), organized the first international symposium Non-CO_2 Greenhouse Gases: Why and how to control?

Since "Kyoto" there is no need anymore to explain the "why": a basket-approach with six (categories of) greenhouse gases has been agreed upon. The question how to control, though answered in many respects, has become more urgent, both from the technological as well as from the policy viewpoint. Countries will have to show their progress in controlling greenhouse gas emissions at the end of the first commitment period around 2008-2012. Therefore, there is a need to explore emission scenarios of non-CO_2 greenhouse gases (NCGGs), to review the present state-of-the-art of existing and emerging approaches to control emissions of NCGGs and to discuss national and international policies which could support their implementation. This review could contribute to the Third Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) for which preparations have been started recently.

In consequence, 1999 seems to be the right time for a Second International Symposium on Non-CO_2 Greenhouse Gases, in order to support the IPCC-process. Therefore, the Dutch Association of Environmental Professionals kindly invites scientists, technologists and consultants, as well as policy makers, stake holders and politicians to participate in this symposium by giving their contributions in the programme and in the discussions.

Themes for NCGG II

The symposium will focus on the non-CO_2 Greenhouse Gases; for that reason papers on general aspects of climate change will not be accepted. Apart from the plenary Opening and Closing sessions, the symposium will be conducted in two or three parallel sessions which will focus on three main themes:

Theme 1: Emission inventories, scenarios and scientific understanding of sources, sinks and atmospheric processes

- remaining uncertainties in emission inventories for the NCGGs from the Kyoto protocol: CH_4, N_2O, HFCs, PFCs and SF_6; this topic may include studies on atmospheric budgets, source strengths, sinks and models connecting these;
- scenario studies for these gases;
- the concept of Global Warming Potential;
- new results on other NCGGs (e.g., ozone)

Theme 2: Technological options

- control techniques for emissions of the Kyoto NCGGs from industrial sources; this topic may include: analysis of industrial processes, the public sector, traffic and consumer goods and options for modification; investigations into low-emission options; substitutes for present applications of NCGGs; recovery of NCGGs from existing applications; destruction of NCGGs; economic potential of control options;
- investigations into biotic processes with relevance for NCGG-emissions; this topic may include rice cultivation; stock breeding; use of fertilizers; agricultural waste disposal techniques; waste water management; forest fires; options for biotic processes will primarily address the emissions of CH_4 and N_2O.

Theme 3: Policy aspects

- identifying barriers for the implementation of low-emission technologies for NCGGs, within countries and between countries and detailed for different sectors;
- development and application of national policy instruments to level existing barriers: financial instruments and their economic effects; emission trading;
- international policy instruments: technology transfer; international investment policies; emission trading; joint implementation;
- verification and compliance; evaluation of national and international policies and programmes; contributions on costing methodology;
- tools for integrated assessment of mitigation options and policies and results of their application;
- connections with other environmental issues.

Conference chairmen

The Conference will be co-chaired by Bert Metz and Ogunlade Davidson, present co-chairmen of the IPCC Working Group III on Mitigation.

Invited contributions

At the symposium a number of invited review papers will be presented.

Call for papers

Participants interested in presenting a paper or poster on any of the abovementioned themes which has not been previously published in the open literature are invited to E-mail an abstract with a maximum of 250 words in English to:

Dr. Joop van Ham,
Coordinator Organizing Committee
c/o VVM-section Clean Air in the Netherlands (CLAN)
P.O. Box 6013
NL-2600 JA DELFT
Tel.: +31-15-269-6877
Fax: +31-15-261-3186
E-mail: j.vanham@plant.nl

Abstracts should be received by 31 December 1998. Notice on acceptance of proposals will be given by 1 March 1999. Authors of selected papers will be asked to prepare a camera-ready-copy paper not later than 1 September 1999 for inclusion in the Proceedings.

Venue

Congress Centre Leeuwenhorst, Noordwijkerhout, The Netherlands, 8–10 September 1999.

Congress language

The congress language is English.

Proceedings

All presentations at the symposium will be included in the Proceedings of the symposium.

Symposium Bureau

VVM
P.O. Box 2195
NL-5202 CD DEN BOSCH
The Netherlands
Tel.: +31-73-621 5985
Fax: +31-73-621 6985
E-mail: vvm@worldaccess.nl
http://www.milieuonline.nl/vvm

Sixth Scientific Conference of the International Global Atmospheric Chemistry Project (IGAC)

Bologna, Italy • 13–17 September 1999

Organized by the IGAC Project of IGBP, The European Commission, and Consiglio Nazionale delle Ricerche-Istituto Fisbat

Deadline for Abstracts is 1 March 1999.

For complete information, see the circular enclosed with this issue or consult the conference web site at http://www.fisbat.bo.cnr.it/IGAC99/.

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IGAC*tivities* Newsletter

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