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In this Issue

GLOBAL IGBP CHANGE
A Core Project of the Internations Geosphere-Biosphere Programme

CACGP
In Cooperation with IAMAS Commission on Atmospheric Chemistry and Global Pollution

A Note from the IGAC Co-Chairs: *Sandro Fuzzi, Phil Rasch and Shaw Liu*

Almost one year has now passed since the publication of the last issue of *IGACtivities*, and during this period the Project has progressed considerably into its second phase: endorsing new tasks, organising specialised workshops and pursuing integration with related IGBP Core Projects i.e. iLEAPS (Integrated Land Ecosystem-Atmosphere Processes Study) and SOLAS (Surface Ocean-Lower Atmosphere Study) as a step towards the implementation of the Earth System approach that is at the core of the IGBP mission.

Certainly the most important activity over the last period was the 8th IGAC Science Conference, held in Christchurch, New Zealand September 4-9, 2004. The latest findings in atmospheric chemistry were shared amongst the 409 attendees from 38 countries. Sessions were organised on iLEAPS and SOLAS related issues in order to foster links with these neighbouring IGBP Projects. Participation of young scientists and their integration into the community was encouraged through a large and very successful set of "young scientist events". The attendance of 62 scientists from 23 countries was supported with funds provided by the three IGAC International Core Project offices, NASA, NSF and WMO. A very successful public event, with Susan Solomon as keynote speaker, was also organised as part of the Conference program in view of the renewed commitment of IGAC for outreach activities towards the public opinion.

A number of science highlights emerged from the Conference that will be of great help in focussing the activities of the present IGAC tasks and in promoting the establishment of new tasks. The main highlights concerned: i) the need for enhanced research efforts on organic aerosols, composition, sources, radiative and cloud nucleating properties; ii) the growing and at times controversial body of information on cloud-aerosol interactions, a fundamental issue in global change; iii) the importance of the link between the gas and aerosol phases and of investigating them as a system, rather than as independent entities; iv) the growing emphasis on atmospheric halogen chemistry and night-time nitrogen chemistry. Continued advances in instrumentation were also presented at the meeting, highlighting the improved time resolution and accuracy of measurements and the increasing importance for atmospheric chemistry of satellite measurements. In line with the emphasis in the IGAC Science Plan on understanding the regional to global impact of large sources of man-made pollution, inter-continental transport and chemical transformation and mega-city emissions were also highlighted as a growing concern by the scientific community. We would like to thank David Lowe, the Science Program Committee and the Local Organising Committee of the Conference for organising this extremely successful event.

This issue describes two tasks recently endorsed by the IGAC Scientific Steering Committee: AMMA-AC (African Monsoon Multidisciplinary Analysis - Atmospheric Chemistry) and DEBITS (Deposition of Biogeochemically Important Trace Species), the latter being an activity with a long history within IGAC that has recently been refocused. A brief science report from a scoping workshop co-organised by IGAC on organic aerosols is also included as a precursor to the journal publication of a more comprehensive synthesis.

Looking to the future of this Newsletter, it is our intention after the long transition into IGAC's Phase II to resume the traditional schedule of quarterly publication and to revitalise the tradition of having its focus be highlighting recent important results in atmospheric chemistry and global change research, with "special issues" devoted to particular topics in the field. We encourage all scientists to collaborate in this effort, proposing "hot" science topics for the Newsletter and eventually offering to act as guest editors for the proposed special issues.

Last but not least, we would like to express our sincere appreciation and thanks to Tim Bates who has left the IGAC SSC after serving as Co-chair over the last two years. Tim, together with Mary Scholes, had also previously taken the burden to ferry the Project across the turbulent waters of the transition phase to the promised land of the new IGAC. We also say goodbye to Martin Manning, who has been a valuable connection to the IPCC. In turn, we welcome three new SSC members: Graciela Raga of Mexico, Martin Randall of Canada and Stuart Picketh of South Africa.

SCIENCE FEATURES

African Monsoon Multidisciplinary Analysis - Atmospheric Chemistry (AMMA-AC): A new IGAC Task

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AMMA (the African Monsoon Multidisciplinary Analysis) is an international integrated multidisciplinary project that aims at addressing both fundamental scientific questions related to the understanding of the West African Monsoon (WAM) variability and the impacts and practical issues related to prediction and decision-making activity. The earliest phase of the project is already underway, with activities starting in 2001.

Here we focus on the atmospheric chemistry component of the AMMA project, specific aspects of which will be conducted as an IGAC Task. For context, below we describe both the larger AMMA project and that aspect that comprises the IGAC AMMA Task.

A full list of researchers that will be participating in the atmospheric chemistry aspect of the AMMA program can be accessed via the on-line Task proposal (http://www.igac.noaa.gov/AMMA_AC.php; Appendix A). Information on the AMMA project in general can be accessed via the following two web pages, and is discussed in some detail herein:

http://amma.mediasfrance.org/index.en.php
http://amma.africa-web.org

I. Motivation and background

West Africa is faced with three major issues where the atmosphere is concerned: **climate variability**, **climate change** and **air quality**.

Climate variability refers to seasonal and annual variations in temperature and rainfall patterns. The climate of the Western Africa sub-region varies greatly from north to south and is mainly governed by the seasonal movements of the Intertropical Convergence Zone. The West African monsoon (WAM) is a coupled land-ocean-atmosphere system characterized by summer rainfall over the continent and a winter dry season. The equatorial belt generally has high rainfall, whereas northern West African countries are typically desert or semi-desert. However, even the parts of West Africa that usually have high rainfall experience climatic variability and extreme events such as floods or droughts. The dramatic change from wet conditions in the 50s and 60s to much drier conditions in the 70s, 80s and 90s over the whole region represents one of the strongest inter-decadal signals on the planet. Indeed, the rainfall deficits of the last thirty years in this area are unprecedented in the 20th century and possibly in the 19th as well. This anomalous period raises questions about the possibility of long-term trends in climate.

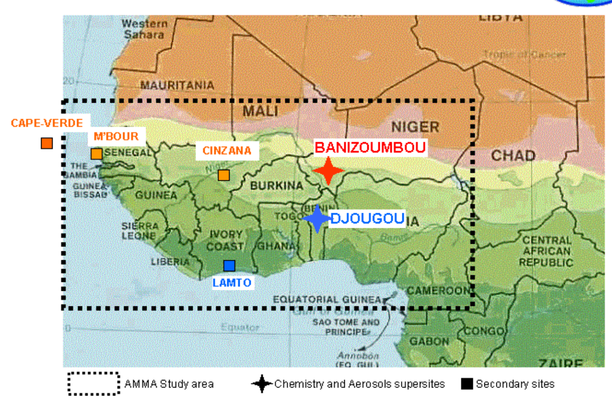


Figure 1 - Map of the regions covered by AMMA observations.

Superimposed on the general aridity of the past thirty years were marked inter-annual variations with some extremely dry years that had devastating environmental and socio-economic consequences. West African populations and economies are heavily dependent on rain-fed agriculture and are therefore vulnerable to rainfall fluctuations. Unfortunately, there are still fundamental gaps in our knowledge of the coupled atmosphere-land-ocean system. These gaps arise at least partly from the lack of appropriate observational datasets but they also are due to the complex scale interactions between the atmosphere, biosphere and hydrosphere that ultimately determine the nature of the WAM. The monitoring system that does exist for observing the WAM and its variability is inadequate. Dynamical models used for prediction suffer from large systematic errors in the West African and tropical Atlantic regions. Current models have problems simulating fundamental characteristics of rainfall such as diurnal, seasonal and annual cycles. Despite significant progress in recent decades in predicting seasonal fluctuations in rainfall much further investigation is needed before fluctuations can be predicted with sufficient accuracy to enable us to anticipate the impact on food production or other human systems.

It is important to recognize the impacts of **climate change** on the West African Monsoon variability and, in turn the role of the emissions in Western Africa on climate change. West Africa contributes relatively little to the global emissions of carbon dioxide compared to the United States or Europe, whether measured in absolute or per capita terms. However, the region has experienced a three-fold increase of per capita emissions of carbon dioxide since 1950. The transport sector contributes the most to carbon emissions, followed by the industrial sector and the widespread use of biomass for energy. On the other hand, West Africa is a major global source of all types of gases and aerosols especially mineral dust and biomass burning products. Consequently huge plumes of desert dust and fire-generated aerosols are seen emerging from Africa during much of the year, and these extend over large areas of the ocean. We also expect that substantial quantities of aerosol are produced by reactions between organic emissions from the large amounts of vegetation that cover large areas of West Africa and emissions from localized urban and industrialized areas. However there is a clear lack of appropriate datasets to properly quantify these emissions and their impact on atmospheric aerosol concentrations and chemical properties.

In turn, West Africa is highly susceptible to the impacts of climate change because of its dependency on agriculture and the limited financial resources that are available for development of mitigation strategies. The IPCC predicts that the greater variability and unpredictability of temperature and rainfall cycles in West Africa resulting from climate change would alter the area of suitable land for agricultural or livestock production and increase the frequency of flooding and drought. Climate change also poses a threat to human health in West Africa, through reduced nutrition and the possible expansion or creation of new habitats for disease-carrying organisms such as mosquitoes (IPCC, 1998).

Latent heat release in deep cumulonimbus clouds in the ITCZ over Africa represents one of the major heat sources on the planet. The meridional migration of the WAM and associated regional circulations impact other tropical and mid-latitude regions so we must expect the atmospheric chemistry and aerosols in WA to impact these regions too. In addition, the presence of such intense sources of aerosols in close proximity to such large regions of deep convection raises questions about the possible impacts of the aerosols on cloud processes. Aerosols could affect convective processes by altering the radiative forcing distribution in the region and also by modifying cloud microphysical processes which, in turn, could change the radiative properties of the clouds,

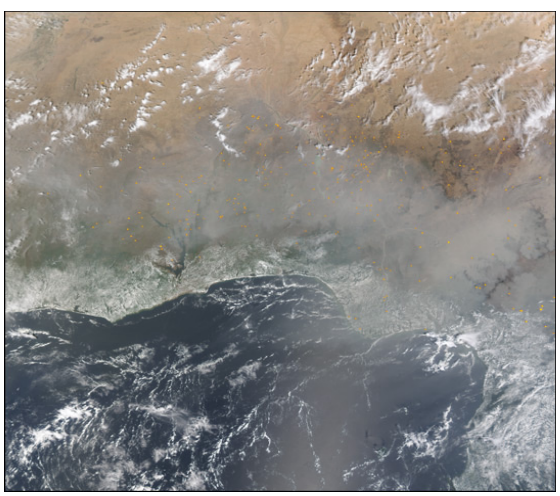


Figure 2 - Dust and Smoke Over West Africa. The West African coastline was partially hidden beneath a thick veil of haze—likely a mixture of dust and smoke from numerous agricultural fires—on February 17, 2004. In this Moderate Resolution Imaging Spectroradiometer (MODIS) image from the Terra satellite, the active fire detections made by the sensor are marked in yellow. (Courtesy NASA Earth Observatory)

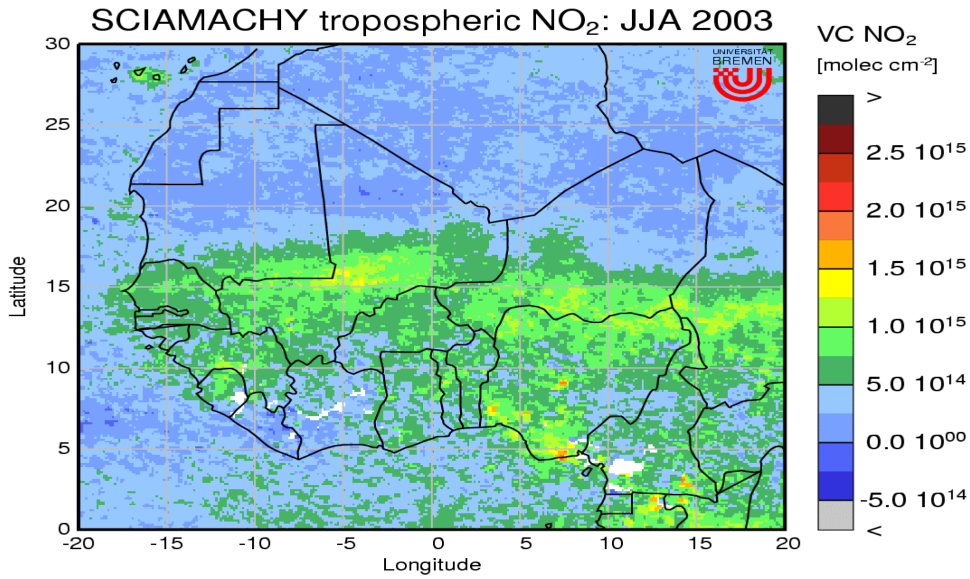


Figure 3 - Mean tropospheric NO_2 vertical column over West Africa during summer 2003 from the ESA/SCIAMACHY sensor. High values of NO_2 vertical column are likely a combination of lightning NOx colocated with the convection and natural emission of NOx from the soils. (Courtesy A. Richter and J.P. Burrows, Univ. of Bremen)

their lifetimes, and the precipitation processes. To date, there is extremely limited information about the chemical composition of aerosols over West Africa, their physical and microphysical properties, and how they impact the climate. Because we know that African aerosols are exported over great distances, these effects could be propagated over large areas. Our knowledge of the extent to which the regional and global radiative forcing and the oxidizing capacity are being perturbed by emissions from West Africa has to be improved.

Air quality in West Africa is an issue that has emerged over the last few decades, particularly in large urban centers. It has been identified as a priority issue for action because rates of urbanization in Africa are among the highest in the world, and there are enormous economic pressures for continued industrial growth. Rapid urbanization and the concentration of economic activities is leading to increasing air pollution from industry, vehicle emissions and mining (e.g. oil) activities. Combustion of traditional fuels (coals, wood, etc.) for domestic energy needs is another major source of air pollution in both urban and rural areas. Poor economic development has also contributed to air pollution by creating dependence on old vehicles and dirty fuels. Pollutants such as sulfur dioxide, nitrogen oxides, hydrocarbons and heavy metals, together with particulate matter, form dense concentrations of smog in urban centers, causing respiratory diseases, contamination of vegetation and water resources and corrosion of buildings.

The objective of AMMA is to quantify the role of West African environmental changes on **human vulnerability** by:

- evaluating the pressures on and changes to atmospheric chemistry resulting from both natural or resulting from human activities,

- understanding of the current atmospheric chemical composition and evaluating qualitative or quantitative trends over the past decades,

- investigating the impacts and consequences of environmental change on human and ecological systems, and on social and economic development potential and,

- guiding societal responses including regional agreements and strategies for cooperation, national policies, awareness and education programs, and community-level projects aimed at addressing both the causes and impacts of environmental change.

Improved understanding of the causes, patterns and consequences of environmental change over West Africa can contribute to the more effective design and implementation of mechanisms to tackle the negative impacts of such change [*Africa Environment Outlook*, UNEP, 2002].

II. Science issues addressed in the IGAC Task

Within the larger framework of the AMMA project described above, the IGAC Task AMMA-AC will address a specific set of questions on atmospheric chemistry in the West African region. These questions have relevance both to air quality and climate. They are:

Question 1: What are the interactions between lightning, biomass burning, the biosphere, the ocean, human activity and growing urbanization which determine tropospheric ozone concentrations over Western Africa?

Improved understanding of the tropospheric ozone budget over Western Africa is needed for the simulations of the West African climate in models used for sub-seasonal to decadal prediction as well as those used for producing scenarios of future climate change. Due to the rather limited studies which have taken place to date in the tropics, the photochemistry of this region is still poorly understood, despite the fact that the tropics are very active in terms of photochemistry. This applies in particular to the free troposphere over West Africa. The tropical troposphere is responsible for ~70% of the total oxidation of long-lived gases such as CH_4, CO, HCFCs and CH_3Br. HO_X ($OH+HO_2$) is the main atmospheric constituent which oxidizes the reduced gaseous compounds, including CO, CH_4, NMHCs, SO_2, DMS, NO_X ($NO + NO_2$) and other hydrogenated and halogenous compounds, into forms more liable to undergo deposition. HO_X and the products of these oxidation reactions are responsible for the majority of in-situ photochemical ozone production and destruction.

The quantification of the HO_X budget is thus a key objective in AMMA. It is also of particular interest in this region because convective injection of species present in the atmospheric boundary layer can be one of the main sources of HO_X in the upper troposphere (see also Question 3). Another important objective relates to the ozone distribution and its budget. In the vicinity of the tropopause, ozone is a particularly active greenhouse gas and it strongly influences photochemistry, as it is a source of HO_X in the presence of UV radiation and water vapor. Therefore, there is a need to determine the contribution of emissions over West Africa to the budget of ozone over this and the larger region affected by West African emissions. This is not an easy task as the West African region experiences an unique superimposition of contributions from different sources which then enter the ITCZ convection. These sources include: moist monsoon air passing over the South Atlantic ocean and the tropical rain forest (biogenic emissions), hot, dry and dusty harmattan air flowing over arid areas and polluted air from urban areas.

The quantification of the sources of trace gases over Western Africa is thus also a key objective of AMMA. The emissions from soils and vegetation in both natural and disturbed ecosystems still need to be quantified. These processes yield emissions of hydrocarbons from vegetation and nitrogen compounds from soils. There is a large variability in emissions depending on the vegetation species and the vegetation and the soil response to rainfall and evaporation related to the monsoon. Anthropogenic pollution resulting from the use of fossil fuels and other human activities has increased in the high population density areas over West Africa. It is clear that there are also important but still unquantified emissions from the large urban areas in this region. Finally, West Africa has one of the most electrically active atmospheres of any region in the world. The production of nitrogen monoxide by lightning in convective clouds is an important source of tropospheric NOx which in turn controls ozone concentrations. Large uncertainties surround the estimates of the magnitude and spatial/temporal distribution of this source.

Question 2: What are the interactions between dust, biomass burning, the biosphere, the ocean, human activity and growing urbanization which determine aerosol production and properties over Western Africa?

Western Africa is one of the most significant aerosol sources in the world. Depending on the season, aerosols in the region are a mix, in variable proportions, of mineral dust (dominant during summer months and northern part of West Africa) and carbonaceous aerosols (dominant during the dry season). Other types of aerosols are present as well including: sulfate and carbonaceous aerosols from the large urban areas, aerosol particles of marine origin which are advected by the monsoon flow, and secondary organic aerosols formed from biogenic gas emissions. The aerosol program in AMMA must take all aerosol species into consideration. The mixing state of the aerosols, their chemical composition, microphysical and radiative properties all need to be investigated over this region.

Quantification of the sources of aerosols over Western Africa is a key objective of AMMA. The natural emissions of aerosols over West Africa are strongly influenced by the climatic conditions at various time scales, either directly via meteorological parameters or indirectly via the vegetation and soil properties. One of the key issue is thus the assessment of the variability of the emissions of aerosols over West Africa due, in particular, to wind erosion and biomass burning activity, and of aerosol precursors from vegetated surfaces. The final objective is to establish the degree to which their variability is related to human activities or to climatic parameters, as for example, the monsoon intensity.

The most productive dust sources in the world are in the Sahara Desert and the Sahel, in areas where human pressures may be making the landscape more susceptible to wind erosion. The quantification of dust emission rates from both natural and anthropogenic (disturbed) sources with high levels of temporal and spatial resolution is a challenge for AMMA. The seasonal variability of the dust emission is strongly linked to the meteorological processes and surface properties. For example, during the wet season, the squall lines are the main event responsible for dust production and deposition in the vegetated Sahel. The characterization of dust emissions also requires the determination of the mineral composition, size and shape of dust particles from ground-based and aircraft measurements.

The main sources for carbonaceous aerosols are biomass and fossil fuel burning, and the atmospheric oxidation of biogenic and anthropogenic volatile organic compounds (VOC). West Africa supports a wide range of natural vegetation which includes tropical humid forests, dry forests and savannah. The tropical savannah in West Africa is periodically burned during the dry season with environmental consequences at a global scale. During the wet season, the biomass burning maximum is located over Central and Southern Africa, with potential advection of these fire-generated aerosols toward Western Africa. Important questions still remain unanswered (elevation, estimate of fuel loads, burned area, emission factors) and there is an urgent need to refine the current estimates of biomass burning emissions and their seasonal and interannual variability over West Africa. Large quantities of wood energy are consumed in West Africa. Fuel wood is thought to constitute 85 percent of the total energy consumption in the West African countries but the fossil fuel emissions estimates are still large.

Given these uncertainties on aerosols production, mix and properties, there is an unique opportunity to address these issues within the AMMA program.

Question 3: What is the role of deep convection, the monsoon circulation and other flow patterns in the transport and processing of these emissions and how do these emissions affect the dynamics of the WAM?

The chemical composition of the free troposphere is intrinsically linked to dynamical as well as chemical processes. Deep convection is important for the transport of trace constituents from the boundary layer into the free troposphere and for the loss of trace constituents by heterogeneous removal processes, including washout. Chemical transformations are carried out via homogeneous and/or heterogeneous processes. Heterogeneous loss processes by aqueous uptake in rain drops, aerosols or ice particles are likely to be particularly active in the tropics because of the extension of cloud cover related to convective activity. However, the details of these processes still requires further investigation. Current treatments of these processes in chemistry transport models need significant improvement and will benefit from the multi-disciplinary studies proposed as part of AMMA. The role of processes – such as stratosphere-troposphere exchange and the penetration of deep convection into the upper troposphere – in determining the chemical composition of the tropical tropopause layer and the transport of trace gases such as water vapor and CFCs to the stratosphere still need to be determined. Similarly, the transport of ozone from the stratosphere (for example across the sub-tropical jet) may be an important and, as yet, unquantified source of ozone in the troposphere.

In turn, aerosols can affect the chemical and physical properties of cloud droplets, cloud radiative properties, and, potentially, precipitation regimes. These interactions could have implications for the regional hydrological budgets. For example recent studies suggest that mineral dust can suppress precipitation in clouds. Thus increased dust during drought cycles could have the effect of exacerbating drought and propagating drought conditions over larger areas. AMMA will provide an opportunity to observe the differential cloud response to very different aerosols (i.e. mineral dust vs. biomass burning aerosols vs. secondary organic aerosols from the vegetation). For example, in the winter months, when dust sources are extremely active in the Sahel and biomass burning is at a peak in the Sudan regions, it should be possible to make transects through lines of convection where clouds are advecting dust from the north and smoke from the south. Thus we can observe whether there are the expected gradients in cloud droplet concentrations and other physical properties.

Question 4: What factors control the outflow of ozone and aerosols (and their precursors) from West Africa to the tropical Atlantic troposphere and how do they impact atmospheric processes in this region?

Once emitted to the atmosphere, aerosols and gases can be rapidly lifted into the free troposphere by deep convection and transported over large distances (several thousand kilometers) away from source regions. As such, emissions over West Africa can affect atmospheric properties and processes on intercontinental and global scales. It is also of interest to understand the propagation of climate-change impacts on this region to the inter-continental scale. One objective of AMMA-AC is to quantify the key transport pathways, photochemical reactivity and aerosol properties in air masses downwind from West Africa, particularly in relation to WAM dynamics with the aim of determining the net export of trace gases and aerosols from West Africa relative to other sources.

The concentration of dust over the tropical Atlantic is strongly anti-correlated with rainfall in the Sahel-Soudano region of west Africa. Thus climate change in Africa (or changes in dust emissions caused by human activities) could affect aerosol concentrations over this large ocean region with the possible result of inducing significant feedback effects. For example, the high optical depths associated with dust outbreaks have the effect of reducing sea-surface temperatures in the tropical Atlantic. In turn it is known that the monsoon cycle is linked to the distribution of sea-surface temperature in the region. In addition, the region off the west coast of West Africa is the spawning ground for tropical storms and hurricanes, many of which impact the continental US. Studies carried out over the past 35 years in this region have shown that African dust outbreaks during the summer months (i.e. hurricane season) are associated with a well-defined meteorological scenario where dust is carried in a hot, dry layer called the Saharan Air Layer (SAL). These interrelated effects will be an important focus in AMMA-AC.

III. The AMMA Program

In order to place the IGAC AMMA-AC Task into context, below we describe the larger AMMA Program.

III.1 AMMA research agenda

AMMA is a multi-year, multi-platform project involving 3 types of observing periods: Long-term Observing Period (LOP); Enhanced Observing Period (EOP); Special Observing Periods (SOP) (*Figure 4*).

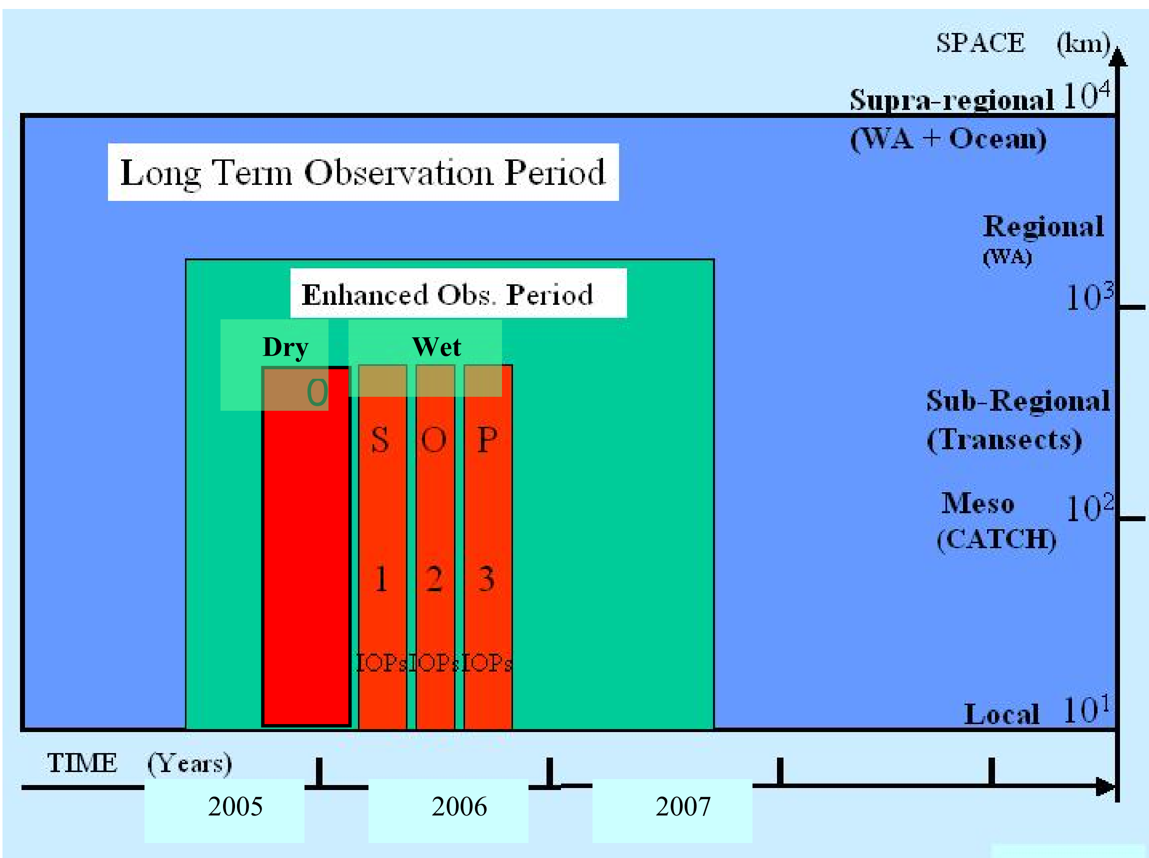


Figure 4 - Timetable of research activities for AMMA.

The Long term Observing Period (LOP)

The LOP is divided into three phases:

2001-2004: The first phase has included

- building an inventory of existing observations;
- co-ordination between observing systems already operating over the region;
- determination of additional required observations –especially for the EOP; and
- building links with national and regional institutions in order to construct an integrated monitoring system.

2005-2007: The second phase of the LOP is the Enhanced Operation Period (EOP see below) during which enhanced levels of monitoring will be in operation.

2008-2010: The core components of the LOP were designed to extend to 2010. These components include the following programs:

AERONET: The AErosol RObotic NETwork program is a ground-based sensing aerosol network with goals of assessing aerosol optical properties and validating satellite retrievals of aerosol optical properties.

CATCH: (Couplage de l'Atmosphère Tropicale et du Cycle Hydrologique) This program aims at monitoring the Ouémé basin in Benin by providing long-term measurements of atmospheric, daily rainfall and hydrologic variabilities.

IDAF: The IGAC Debits Africa program is a ground-based network established with the objective of determining atmospheric depositions and aerosols composition and size in Africa. (See related article on DEBITS in this issue of *IGACtivities*).

IMPETUS: (Integratives Management-Projekt für einen Effizienten und Tragfähigen Umgang mit Süßwasser) The objective of this program is to analyse the interdependences between resource availability, socio-economic, and demographic development, in order to assess different development strategies regarding resource utilisation and food security in Benin until 2020.

Co-ordination between these various projects will remain essential during this last phase of the LOP. It is also foreseen that, so far as EOP measurements demonstrate the benefit of enhanced observations for weather and climate prediction, the operational networks will be maintained at a higher level of readiness and will continue to provide data to the wider scientific community.

The Enhanced Observing Period (EOP)

The EOP is designed to serve as a link between the LOP and the Special Observing Periods and is planned to be of 3 years duration. It starts in January 2005. The EOP is thus designed to enhance the LOP so as to obtain a better understanding of some key factors that may play a role in inter-annual variability and to provide a framework for the SOP. The main EOP objective is to document, over a climatic north-south transect, the annual cycle of the emissions and of the atmospheric state variables at convective to synoptic spatial scales. In addition, an aim of the EOP is to go beyond a simple documentation of the WAM variability and to investigate some mechanisms that may explain this variability. To this end, AMMA will provide key enhancements to the sustained observing system needed to support the analysis of the seasonal-to-inter- annual variability of the gases and aerosols in the West African Monsoon (WAM). AMMA will coordinate these enhancements with existing long-term monitoring projects in West Africa (AERONET, IDAF, MOZAIC). The long-term observing strategy over the continent will take advantage of the strong surface observational network that has been established through the CATCH hydrological project. AMMA will strengthen the atmospheric observations along this meridional transect through provision of a set of basic ground-based measurements (see on-line Task proposal http://www.igac.noaa.gov/ AMMA_AC.php; Appendix B). A major focus will be on improving radiosounding coverage, adding ozonesondes, and establishing surface flux stations (aerosols, chemical species, water, energy) over the continent. Such observations are not carried out operationally and are not currently part of the LOP.

The Special Operation Period (SOP, 2006) will provide a multi-scale and multi-process analysis of one monsoon season. The measurement phases and their tasks are summarized as follows:

SOP 0: The dry season and aerosols experiment (January-February 2006)

This SOP will serve to measure aerosol properties (physical-chemical and optical properties) to characterize the dust and biomass burning aerosols and their variability over dust production areas and in the vicinity of fires. A second focus of this period will be the validation of Aura, Parasol, Calipso and Cloudsat satellite retrievals.

SOP 1: The monsoon onset (May – June) and the chemistry of the low and mid-troposphere.

The aim of this SOP is to study the coupled system: « Saharan thermal low / monsoon flow / African Easterly Jet ». In parallel with the evaluation of the energy budget (heat, momentum, humidity), it is necessary to quantify concentrations and fluxes of trace gases at the surface (including emission and deposition) and in the atmosphere, and to compare the results before and after the arrival of the monsoon flow. Aerosols and their properties will also be measured at many sites during all SOP stages.

SOP 2: The monsoon maximum (July – August) and the atmospheric chemistry during the monsoon.

The goals of the SOP 2 are to investigate the propagation and evolution of the precipitating systems including their interactions with synoptic scales; to measure the chemical components in the upper troposphere and tropical tropopause layer (TTL) zones; and to study aerosol mix, clouds and radiative effects.

- ***« Budget of ozone and HO_X radicals in relation with precipitating systems »*** The main objective is to quantify the tropospheric budgets of HO_X and O_3 in the presence of convective precipitation. Measurements in the instrumented zone will be a first priority.
- ***« Characterisation of the tropical tropopause layer (TTL) »*** The objective is to measure the chemical components in the TTL zone between 13 and 17 km altitude, which is above the strongest convective outflow and below the thermal tropopause. This region is characterised by important interactions between the troposphere and the stratosphere which must be correctly understood to provide a reliable lower boundary condition for stratospheric chemistry.
- ***« Aerosols, clouds and radiative effects »*** The objective concerns the influence of precipitating systems on lower tropospheric concentrations of both natural and anthropogenic aerosols. A second objective concerns studying the interactions between aerosols and the microphysical and radiative characteristics of clouds, especially the convective clouds, those at high altitude (e.g. cirrus) and those that have long duration (e.g. anvil remnants).

SOP 3: The late monsoon, the tropical Atlantic (August – September) and the long range transport of chemical constituents.

The goal of this SOP is to study the transformation of the meso-to-synoptic scale perturbations passing from the West African continent to the warm waters of the tropical Atlantic; the influence of environmental conditions, particularly the presence of dry Saharan air in the mid-troposphere; the intercontinental transport of gases and aerosols over the Atlantic Ocean; and their contribution to the global oxidising capacity and radiative forcing on a global scale.

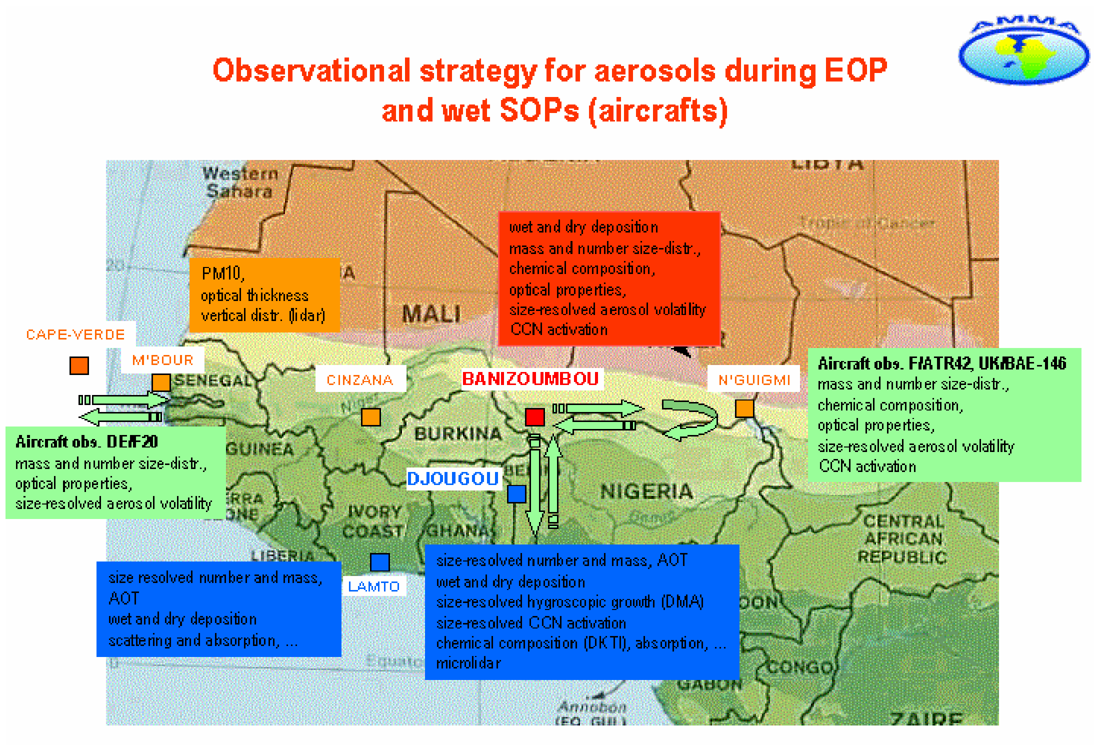
III.2 AMMA research tools & experimental strategy

Current observing systems do not provide all the information needed to fully understand and quantify multi-scale and multi-process interactions. The spectrum of scales to cover is very broad, ranging from local (cloud complexes) to regional (the whole of West Africa) and beyond (global). The observation strategy will thus associate operational observations with long-term observations that are concentrated in a sub-regional window. These will obtained from various ongoing research projects (c.f. AERONET, IDAF). The atmospheric chemistry specific objectives will directly benefit from the meteorological support (improved radiosonde network, dropsondes, radars, etc). During the SOPs, EOP equipment will be greatly enhanced in order to study different processes in great detail within the framework of the focused field campaigns. Airborne instruments will be operated during the Special Observation Periods.

Great attention will be paid to collecting and archiving historical datasets in close collaboration with researchers in the African countries in the AMMA study region. In addition, intensive multi-disciplinary observations will be performed during specific periods, focusing on the understanding of key processes. The utility of enhancing existing monitoring stations with additional observations for the future will be tested using modeling and assimilation systems.

AMMA instrumented zone during the SOPs:

For SOP 1 and 2, the region where intensive observations will be conducted is a sub-regional scale window currently covered by the CATCH measurements. The plan is to establish an ensemble of instruments aimed at quantifying the mass and energy budgets (i.e. heat, humidity, radiation, momentum, trace gases) over a zone that covers Benin and the region of Niamey in Niger. This region will be the CATCH -focus area- which extends between 5°N-17°N and 5°W-5°E. These special observations must be considered in relation with the larger scale and will permit linking the observed local processes with the regional and synoptic scale forcing. In addition to this ground-based equipment, instrumented aircraft will be extensively used to provide a more complete coverage of the observed events, both spatially outside the instrumented zone or the CATCH sub-regional window and temporally to follow the evolution of the selected events as they propagate over West Africa. During SOP 3, sone or two instrumented aircrafts will be based in Dakar, Senegal, or in Sal, Cape-Verde Islands.



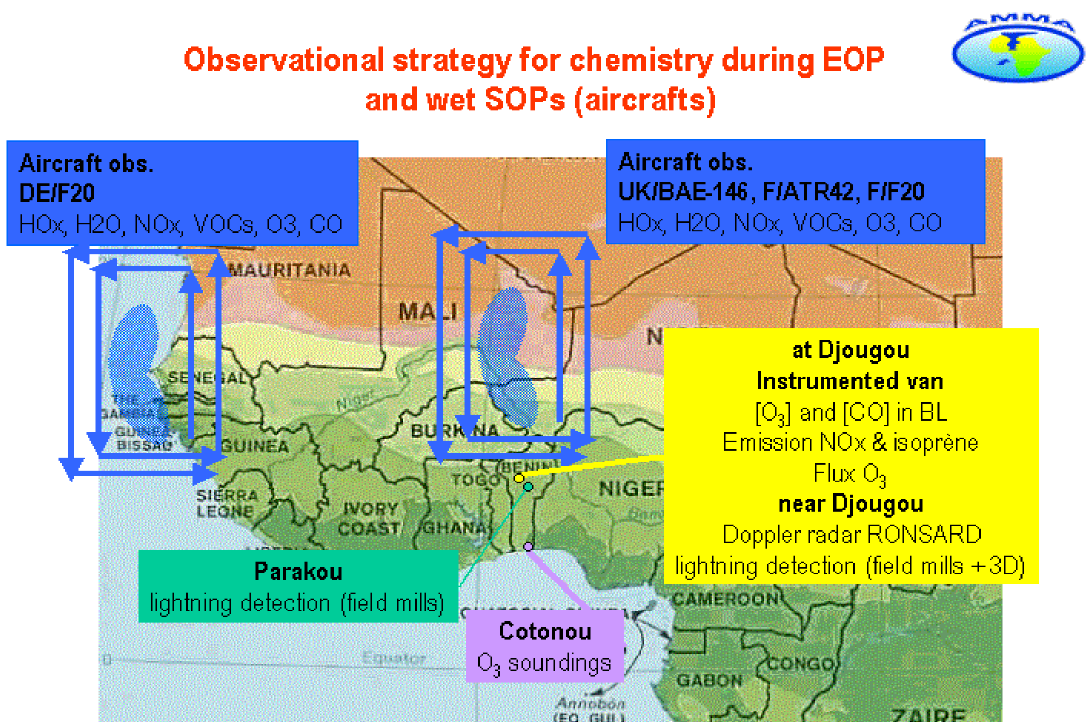


Figure 5 – Multiple air- and surface-based platforms will be used during AMMA to constrain aerosol fields (top) and gaseous chemistry (bottom).

Instrumented platforms:

Aircraft

Multiple aircraft will provide data from the dropsondes, Doppler radar, and flight level measurements. Aircraft dropsondes will enhance the ground-based radiosonde network over the continent and will extend this land-sounding coverage into the continent and the ocean by sampling the data-poor region (both along and across the ITCZ). Aircraft Doppler radar will supplement the ground-based radar network over land and ocean. Flight-level measurements will sample detailed properties of the aerosols, gases, radiation flux, and clouds.

To quantify the HO_X, ozone and aerosols budgets in the free and upper troposphere, a minimum set of observations is required: ozone, CO, H_2O, NO, NO_2, PAN, HNO_3, NO_Y, CH_4, N_2O, peroxides, carbonyls, OH, HO_2, SO_2, H_2SO_4, acetone, formaldehyde and aerosol composition, size distribution and optical properties. Airborne measurements of acetaldehyde (CH_3CHO) and methanol would also be very interesting for understanding the HOx budget. Measurements of radionuclides, alcohols and remote H_2O would also be extremely valuable.

Four aircraft are currently planning on participating on the SOP covering a large suite of measurements (see on-line Task proposal http://www.igac.noaa.gov/AMMA_AC.php; Appendix C). These include: the United Kingdom BAE146 aircraft (contact Claire Reeves, c.reeves@uea.ac.uk), the instrumented French aircraft INSU/ATR 42 (contact Gerard Ancellet, gerard.ancellet@aero.jussieu.fr) and the German (contact Hans Schlager, Hans.Schlager@dlr.de) and French F20 aircrafts. The participation of the Russian high altitude aircraft Geophysicae is currently under investigation.

Satellite observations (ENVISAT, AURA, AQUA-Train, TERRA) will strongly contribute to the objectives of the project by providing measurements in biosphere-atmosphere system). In turn, the AMMA project will provide a unique set of integrated ground observations that will be used for validation of retrievals from the current and planned satellites.

Modeling and assimilation

To address the objectives of AMMA, a synergistic approach cutting across disciplines and across spatial and temporal scales is necessary. The main tool will be numerical modeling and assimilation and a major objective will be to evaluate and improve the numerical prediction of weather and climate over the West African region.

A hierarchy of models is now available to treat a very broad range of scales and the atmospheric, oceanic and chemistry processes involved in the WAM. These include Global Climate Models, Chemical Transport Models, mesoscale models and cloud resolving models. These atmospheric models have the same problems as weather forecasting models; close collaboration between these modeling communities will improve the physical parameterizations in these models. It is crucial to improve the representation of convective processes at cloud scale in terms of the dynamics and thermodynamics and also to understand the impact of convective clouds on the vertical transport and scavenging of gases and aerosols. At the regional and synoptic scale, atmospheric and chemistry models focus on the dynamics of the African Easterly Jet, the meridional gradients and surface fluxes, and the dry and wet convection. These major dynamical features have a great impact on the location of origin and chemical composition of air masses in the convective outflow, which is transported over large distances. In turn, the spatial distribution, chemical properties and size of the aerosols in West Africa represent a complicated superposition of contributions from different African source regions (oceanic, combustion, urban pollution and desert). Chemistry models have to take into account this variety in order to evaluate the radiative impact of the aerosols and their effect on the dynamics. The numerical strategy will be based on a multi-scale approach from the local scale of a convective cell to the climatic impact. This approach has been followed successfully in the GCSS (GEWEX Cloud System Studies) framework and it should be extended to include atmospheric chemistry.

Ground-based platforms

- **AERONET** (contact Philippe Goloub, goloub@univ-lille1.fr)

The understanding of the mixing state of aerosols and their radiative properties will rely on ground measurements in the framework of the AERONET network. A climatology of aerosol optical thickness and the relation with the monsoon phenomenon based on the AERONET database is still needed. An additional station will be installed in Djougou.

- **IGAC-DEBITS-Africa (IDAF)** (contact Corinne Galy-Lacaux, lacc@aero.obs-mip.fr)

IDAF-Africa belongs to the global network DEBITS providing chemical measurements in wet and dry depositions at various African regional ecosystems (6 stations in Western and Central Africa and 3 in South Africa).

- **Instrumented sites for chemistry and aerosols**

Two supersites for chemistry measurements are equiped in the sub-regional CATCH window:

- Djougou in Benin (contact Cathy Liousse, lioc@aero.obs-mip.fr)
- Banizoumbou in Niger (contact Jean-Louis Rajot, rajot@lisa.univ-paris12.fr) .

Secondary sites with basic instrumentations will operate during the EOP:

- Lamto, Ivory Coast is a second site for the study of the aerosol mix
- Cinzana -Mali- and M'Bour -Senegal complement the Sahelian transect for the study of dust transport and deposition
- Cape Verde -Senegal- is the site for studying the West African outflow of aerosols and gases

Measurements of ozone and ozone precursors

Ozone sondes will be made on a weekly schedule in the instrumented zone (Cotonou) so as to characterize ozone's vertical distribution and seasonal variability. These sondes will complement the measurements of ozone and CO made on board commercial aircraft in the framework of the MOZAIC program.

Measurements of ozone and its precursors will be enhanced by the instrumented site of Lamto in Ivory Coast and Djougou in Benin.

Emission measurements (biogenic and anthropogenic)

Emissions inventories from natural and disturbed ecosystems should benefit from data bases on soil and vegetation obtained in field experiments conducted in the last 20 years, and from satellite data which provide parameters like the vegetation index (NDVI) and leaf area index (LAI). Another important use of satellites in building emission inventories is through fire detection and the estimation of burned areas using data from sensors such as AVHRR (Advanced Very High Resolution Radiometer, NOAA) and ATSR (Along Track Scanning Radiometer, ERS1). Ground-based measurements of gas species (vertical profiles, vertical fluxes, surface concentrations) are highly desirable to complement the satellite information. These measurements should be done on latitudinal and longitudinal transects and during at least two seasons to capture their high spatial and temporal variations. Ground measurements are also required in urban areas to quantify the increase in urban and industrial pollution. Desert dust emissions will be measured in a few selected dust source areas.

IV. Applications, training and education

In the planning of AMMA, significant attention has been paid to generating benefits that move beyond answering the scientific questions and whose duration extends beyond the period of the project. Below we describe some of these benefits.

Building capacity in partnership with African Institutions

A key aspect of the AMMA project is the development of blended training and education activities for African research and technical institutions. As of September, 2004 three scientists from West Africa are present on the international organizing committee for AMMA: Cherif Diop (Sénégal), Abou Amani (Niger), Leykan Oyebande (Nigéria). In addition, researchers from the major West African environmental laboratories are involved in AMMA through the IGAC/IDAF network, a component of the IGAC DEBITS Task.

Further, a major objective of the project is to build links between scientific research and the application of what is learned to policy decisions. Models and data sets will be developed in collaboration with African institutions and international bodies so that they can test and use them as tools for decision making and to develop adaptation strategies in response to the evolving West Africa environment. The collaboration between scientists working on processes and those involved in applications will be fostered through training sessions. The project will also provide updated global climate change scenarios for stakeholders. Summer schools, supervised PhDs, visiting scientists opportunities for African scientists and participation of researchers outside Africa and teaching in African Universities are among the various tools that will be used to build a strong link with African scientific communities. Such links already exist at national levels through specific programs but the project will provide the opportunity to develop and promote these efforts.

Communications between all AMMA participants have been and will continue to be facilitated by a web-based tool, the AMMA community network, AMMANET. Since 2002, West African scientists – from both universities and national meteorological and hydrological services – have collaborated via AMMANET (http://www.ird.ne/ammanet/). AMMANET is coordinated by a steering committee of 7 scientists, including: Abou Amani, (Hydrology, AGRHYMET Centre - Niamey, Niger); Amadou Gaye (Lecturer at LPA - Dakar, Senegal); Adamou Garba (Lecturer at EAMAC - Niamey, Niger); Abdallah Nassor (ACMAD - Niamey, Niger); Delphin Ochou (Lecturer at LAPA - Abidjan, Ivory Coast). In addition, each African country involved in AMMA has identified a national coordinator. This contact person is in charge of producing reports about the AMMA activities and collaborations in her country. AMMANET will contribute to the reinforcement of the capacities of the various national or regional institutions and the universities. The national committees must regularly organize meetings to discuss the scientific aspects and co-ordination between the various teams.

Finally, we note that travel and educational support for the West African partners will be funded via the EU and French Integrated Project.

Monitoring strategies

AMMA will implement a multi-scale and integrated monitoring network, providing key parameters for multidisciplinary scientific investigation and prediction. Based on the results of the campaign, as set of recommendations will be made on how to optimize existing measurement networks by the addition of new measurements/instruments. This will satisfy an important demand of African services and regional agencies.

Socio-economic implications

The results of the AMMA project will help to characterize the impact of West African climate variability on water resources, food security, health and development strategies and to explore the feedback of human activities on climate variability, since anthropogenic pressure plays an important role in land degradation.

Long-term archiving system

As part of AMMA, there will be a meta-database and interoperable databases focusing upon the themes of the project. The database will be operated by MEDIAS-France and will insure public access to the data. A common data protocol for members of the AMMA consortium of investigators needs to be developed.

Peer-reviewed manuscripts

Results from AMMA will be published in peer-reviewed journals. Approximately 1-2 years after the SOPs in 2005 or 2006, a special section in a journal is planned. The targeted journals are not yet decided.

International cooperation

Currently, scientists from more than 25 agencies/institutions in more than 20 countries in Africa, Europe and the U.S. are involved or will be involved in the AMMA project. These countries include: Algeria, Benin, Burkina Faso, Cameroon, Chad, Denmark, France, Germany, Ghana, Italy, Ivory Coast, Mali, Niger, Nigeria, Senegal, Spain, Togo, UK, and the US.

Links to other IGBP Programs

The multidisciplinary nature of AMMA is such that it has links with several IGBP programs. In addition to IGAC, the IGBP Core Projects ILEAPS (Integrated Land Ecosystem-Atmosphere Process Study; covering emissions, deposition, biosphere-atmosphere interactions) and SOLAS (the Surface Ocean Lower Atmosphere study; covering atmosphere-ocean interactions) have endorsed this proposal. In addition, the Earth System Science Partnership's IHDP (International Human Dimensions Program; covering the impacts of climate change on human kind) may be involved in AMMA.

DEBITS (Deposition of Biogeochemically Important Trace Species) enters Phase II as an IGAC Task

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Wet and dry deposition of chemical species to the earth's surface plays an essential role in controlling the concentration of gases and aerosols in the troposphere. The chemical content of atmospheric deposition is the signature of several interacting physical and chemical mechanisms such as: emission and source amplitude; transport in and dynamics of the atmosphere; atmospheric chemical reactions; and removal processes. The study of deposition thus allows for tracing the temporal and spatial evolution of atmospheric chemistry and is a pertinent indicator for evaluating natural and anthropogenic influences. In regions where biogeochemical cycles are disturbed by human activities, atmospheric deposition can be either an important source of toxic substances or a source of nutrients for the ecosystems. Having an understanding of chemical deposition is therefore an essential aspect of a global interdisciplinary approach to developing a predictive capacity for the input of the main determinants into the functioning ecosystems.

Under IGAC, DEBITS (Deposition of Biogeochemically Important Trace Species) was initiated in 1990 to serve as a "catalyst" for encouraging existing and new activities in the final step of biogeochemical cycles: the deposition of chemical species. A decade of DEBITS research has produced many scientific insights, as highlighted in a previous *IGACtivities* Newsletter (No. 27, Jan. 2003; http://www.igac.noaa.gov/newsletter/igac27/Jan_2003_IGAC_27.pdf). Following this successful first phase of DEBITS, the project team updated their scientific objectives, building on what was learned over the past decade and proposed this as a new task under IGAC Phase II. DEBITS officially entered its second phase with the endorsement of this proposal by the IGAC SSC this past February.

The first decade of DEBITS

The organizational framework of DEBITS centers around three programs established in the first phase of DEBITS which aim to studying deposits in three regions:

DEBITS in Asia (CAAP) began in 1990 and was originally an IGAC task entitled "Composition and Acidity of Asian Precipitation" (CAAP), initiated by the Department of Meteorology at Stockholm University (MISU) and the Division for Atmospheric Research, CSIRO, Melbourne. The main objectives of CAD are:

- to determine, primarily through measurements, the atmospheric removal rates by dry and wet deposition of biogeochemically important trace species in South and South-East Asia.
- to establish at regional scale atmospheric budgets of key elements (S, N, Ca).
- to relate the deposition fluxes to the sensitivity of soils and surface waters.
- to obtain data for testing regional transport models of sulfur and nitrogen pollutants.

In 2000, the CAD program emphasis was shifted to de-emphasize the rainwater acidity issue and expand the goal of including dry deposition measurements.

DEBITS in Africa (IDAF) was created in 1994**,** acknowledging the global importance of biomass burning, land use change and industrialization resulting from rapid population growth. The IGAC DEBITS Africa (IDAF) objectives, which consider the contributions of biomass burning and desertification (soil dust) to atmospheric chemistry specifically in Africa, were defined as follows:

- to estimate, from measurements of wet and dry deposition fluxes, important chemical species (especially N, C (i.e. organic aerosol) and S) at regionally representative sites.
- to identify the relative contributions of natural and anthropogenic sources to these deposition fluxes.

DEBITS in Amazonia is one of the activities comprising the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA; http://lba.inpa.gov.br/lba/). One aspect of these five deposition stations' foci is to determine the importance of the atmospheric part of the nutrient cycle from natural and secondary forests and managed lands. Important results have shown the crucial role of the vegetation cover in determining aerosol and CCN concentrations, as well as water balances in the region and the many potential feedbacks between the ecosystem and the physical and chemical climate of the region.

DEBITS science early in phase I focused on achieving uniform, quality-controlled measurements in each of these three programs. In 1998, the goals were refined to include the not only determining the deposition rates of key species but also their atmospheric budgets at the regional scale; to ascertain the chemical and physical factors that regulate deposition fluxes; and to develop parameterizations that could be integrated into regional and global atmospheric chemistry models. Some of the scientific achievements to this end of DEBITS under phase I are described in a special issue of the *IGACtivities* Newsletter No. 27 (http://www.igac.noaa.gov/newsletter/igac27/Jan_2003_IGAC_27.pdf), as well as in the peer-reviewed literature.

Future Plans

Within the new structures established for IGBP Phase II, the DEBITS science community plans to adopt a two-fold approach:

1) *To maintain the present operational structure of DEBITS, including the strong regional focus of its three core programs (CAD, IDAF and LBA) and the scientific collaborations that are already well established.* It is critical to pursue the actual scientific work and increase activities in dry deposition measurements and associated modeling activities. New measurements aimed at addressing gaps identified in previous phases of DEBITS will be introduced at all the sites. These include trace

metals in aerosols and rain, size discrimination for aerosols, and carbon measurements in aerosols and rain. The atmospheric chemistry processes that regulate deposition within various compartments (e.g., gas-aerosol particles-clouds) still pose important un-answered questions that need to be addressed in the second phase of the IGAC program.

2) *To support a new integrated approach within the global scientific context of IGBP in it's second phase.* A strong networking and data-sharing approach with other IGBP programs such as ILEAPS (Integrated Land-Ecosystem Atmosphere Process Study), GLP (Global Land Project) and SOLAS (Surface Ocean Lower Atmosphere Study) is envisaged. In Africa and south Asia, the AMMA (African Monsoon Multidisciplinary Analyses) and CAD (Composition of Asian Deposition) projects should include the IDAF and CAAP network activities, while the integrated approach of deposition studies in LBA will be continued for the foreseeable future. This integrated approach deals with (1) atmospheric chemistry studies at the interface of continental and marine environments and (2) associated impact studies. An integrated social, economic and physicochemical approach to Earth systems will maximize the value to society of large international and integrated research efforts.

Finally, the historical links between DEBITS and the WMO GAW program (http://www.wmo.ch/web/arep/gaw/gaw_home.html) and WMO regional networks will be maintained and strengthened through DEBITS becoming a "contributing partner" of this initiative.

The underlying principles of the new DEBITS II task is to promote and facilitate international atmospheric deposition research that will lead to a better understanding of responses and feedbacks within the Earth System. The task is driven by scientific questions related to global atmospheric chemistry, and its activities will be focused in regions of high impact on sensitive ecosystems and human health. The specific scientific questions being addressed under the second phase of DEBITS are:

- What are the atmospheric removal rates via dry and wet deposition of biogeochemically important trace species on a temporal and spatial basis at regional to global scales?
- What are the key regulating processes (interaction gas/aerosol/cloud/ecosystem) that affect deposition?
- What are the roles of heterogeneous chemical processes in: modifying the chemical composition of atmospheric particles; partitioning between the gaseous and particulate phases; changes of the physio-chemical properties of aerosols; and causing subsequent changes in dry versus wet deposition?
- What are the regional scale atmospheric budgets of key elements?
- How can the use of numerical models assist in quantifying relationships between emissions and depositional fluxes and provide an integrated scientific assessment of the atmospheric C, S and N cycles, specifically at the regional scale?
- How can deposition flux measurements be related to impact studies? Here there will be a special focus on the deposition of nitrogen and other key species for ecosystems and hydrology, such as phosphorous.

Quality assurance and methodologies

The scientific activities of DEBITS are mainly based on quality-controlled measurements of precipitation chemistry to quantify wet deposition, as well as aerosol and gas concentrations to estimate dry deposition. DEBITS stations, representative at the regional scale and specially instrumented to measure or estimate atmospheric deposition parameters, have to be maintained or created for long-term time-series. Additional measurements, permitting a better estimate of depositions, will require field experiments dedicated to atmospheric chemistry at the regional scale. The inclusion of data of mega-pole sites in DEBITS II is aimed at determining the impact of urbanisation and anthropogenic activities in general on the Earth System.

Wet deposition measurements will be continued using a standardised rainwater sampling, preservation and chemical analysis procedure. Meteorological rain gauges are used for the evaluation of wet deposition at all the sites. To obtain comparable data sets for precipitation chemistry with high quality assurance, an experimental strategy comprised of:

- wet-only sampling on a daily period;
- preservation of the chemical content by a biocide or by freezing;
- quality assurance by using the US EPA criteria based on ionic and conductivity balances, annual analytical laboratory performance checks with a WMO protocol for chemical analysis;

will be employed.

Dry deposition quantification for gases and particulates will require the continued monitoring of concentrations by passive gas sampling for SO_2, NO_2, NH_4(gas), HNO_3, O_3 and VOC's. In the same way, dry deposition of particles will be estimated from either from bulk measurements or from measurements in two size classes (PM 2.5 and PM 10.0) by sampling air on membranes and using standardised chemical analysis. Direct flux measurement methods, such as Eddy Correlation or Eddy Accumulation, which have been used in field programs in tropical areas as well as other regions, will provide a data set of deposition velocities suitable for determining dry deposition rates from the measured ambient concentrations at the DEBITS sites.

Data management and archiving

In consultation with contributing partners and potential users, participating scientists in the new DEBITS II task will:

- adopt a uniform strategy for data acquisition and management;
- build regional databases of field observations (gas, rain, aerosol) for testing regional and global models (with interactive bio-chemical and physical models);
- support capacity building, technology and knowledge transfer on a global scale.

Moreover, the DEBITS II programme plans to initiate a DEBITS web site that will include general information and a meta-data base using the ISO 19115 format. This web site will have a description of the measurement sites, the experimental methodologies of the DEBITS network and a list of general documentation concerning atmospheric deposition and integrated results produced by the DEBITS II activity. The DEBITS web site will be mirrored in the web sites of the three core programs (CAD, IDAF and LBA). For the scientific community not linked to Internet, a CD-ROM will be also produced.

Educational and capacity building

DEBITS has a proud record of capacity building in the developing countries. Educational and capacity building activities will be continued by:

- having workshops and short summer schools in developing countries;
- fostering student and staff exchange within the DEBITS science community;
- seeking support for capacity building initiatives at international funding agencies such as Sida (Swedish International Development Co-operation Authority), WMO and START.

Timetable & Milestones

The timetable of DEBITS is in accordance with the goal of creating, maintaining and expanding a long-term time-series of measurements of controlled precipitation chemistry to quantify deposition. The activities included in the three regional programs are all aimed at providing data that would benefit studies on interannual-to-decadal variability of deposition fluxes of biogeochemically important trace species. In the new phase of DEBITS II, special emphasis will be placed on the synthesis of data already collected in previous phases as well as the inclusion of new parameters and insights into future studies (e.g. the inclusion of carbonaceous species, aerosols and particles). This action of DEBITS will be synchronized with scheduled bi-annual IGAC conferences in order to create sufficient time for bi-annual regional workshops and meetings.

In agreement with the philosophy outlined above, the following time schedule was drawn-up by the Coordinating Committee:

- October 2003: Coordinating Commitee prepares task proposal for the IGAC SSC
- November 2003: Regional meetings (CAD in Delhi 4 to 6 November, IDAF 14 November and LBA before next meeting) organise by regional programmes
- 2004: Prepare meta-data base form to be completed by participants
- September 2004: DEBITS science meeting, IGAC conference, Christchurch, NZ
- 2005: Regional workshops and meetings
- September 2006: DEBITS data synthesis workshop and IGAC conference, Cape Town, South Afica
- 2007: Regional workshops and meetings
- 2008: DEBITS data synthesis workshop and IGAC conference

Within the regional programs, various enhanced monitoring and data analysis activities is planned to improve the understanding of deposition processes and impacts on a regional scale. DEBITS scientists will also participate in special field campaigns focused on addressing regional specific needs and questions (e.g. the AMMA task in Africa; see previous article in this issue of *IGACtivities*).

The following milestones are considered to be important in the new phase of DEBITS:

- The establishment of a DEBITS web site that will include general information and a meta-data base using the ISO 19115 format (2005)

- Intercomparison of the LBA, IDAF and CAD data sets (2006)
- Modeling depositional fluxes and providing an integrated scientific assessment of the atmospheric C, S and N cycles (2007)
- Relate deposition flux measurements to impacts (2008)

These milestones will be assessed by the number and impact of papers generated by participating scientists. The support given by DEBITS to other shorter-term programs like AMMA and others are also regarded as important.

Names and contact addresses of the task coordinator(s)

DEBITS II is intended to be as inclusive as possible and invites the participation of all interested scientists.

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Organic Aerosols and Global Change: A report from the joint IGAC – iLEAPS – SOLAS workshop 10 - 12 May 2004 Hyytiälä, Finland

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Organic aerosol (OA) components account for a large fraction of atmospheric particulate matter (up to > 80 %). They influence the physical and chemical properties of aerosol particles and thus have effects on the atmosphere and climate through interaction with reactive trace gases, water vapor, clouds, precipitation, and radiation. Organic aerosols also influence the biosphere and human health through the spread of micro-organisms, impacts on respiratory and cardiovascular function, and through allergic diseases. However, at present our understanding of OA composition, physical and chemical properties, sources, and transformation characteristics are very limited, and estimates of their actual environmental effects are highly uncertain. Potentially important feedback loops exist, such as biosphere-aerosol-cloud-climate interactions. For example, changes in organic emissions will affect CCN concentrations and could thus significantly affect cloud properties and precipitation regimes, in turn altering the biologic productivity, which itself leads to further changes in emissions. However, the importance of such feedbacks are still speculative, especially on a global scale. Reduction of these uncertainties will require a comprehensive characterisation and investigation of OA by laboratory and environmental chamber experiments, field measurements, remote sensing, and modelling studies. Moreover, to be effective these studies require efficient planning and coordination such that there is exchange of research activities and results within the international scientific community and so that the envisioned activities lead to filling the gaps in estimating climatic impacts.

Recognizing this, the three atmosphere-related projects of the International Geosphere Biosphere Progamme (IGBP) – IGAC (International Global Atmospheric Chemistry Project), iLEAPS (Integrated Land Ecosystem Atmosphere Process Study) and SOLAS (Surface Ocean-Lower Atmosphere Study) – organised a workshop on organic aerosols which was held in Hyytiälä, Finland, 10-12 May, 2004. The organising committee was comprised of Sandro Fuzzi, Meinrat Andreae, Barry Huebert and Markku Kulmala.

The specific goal of the meeting was to discuss and prioritize issues related to organic aerosol and their effects on atmospheric processes and climate, providing a basis for future collaborative activities among the three projects at the international level. The workshop was organised around four sessions centred on the following topics:

- sources of organic aerosols
- transformation of organic aerosols
- the physical and chemical state of organic aerosol
- modelling organic aerosol processes

Each session had a few short presentations followed by a general discussion, where two rapporteurs summarised the session discussion. These summaries and the detailed workshop discussions were synthesized into a report outlining key outstanding issues and research recommendations for each of the topic areas given above. The report is being submitted for publication to Atmospheric Chemistry and Physics Discussions. Some of the issues addressed in detail in the publication are highlighted below:

Secondary Organic Aerosol: How to define?

Organic aerosols result from both primary emissions (primary organic aerosol; POA) and through nucleation and condensation of gaseous organic species. The latter processes may result in new aerosol formation and/or in the growth of existing aerosol, thereby altering aerosols' microphysical, chemical and optical properties, as well as their efficiency as cloud condensation nuclei (CCN). Traditionally, those organics emitted as gas species and which later form aerosol have been termed secondary organic aerosol (SOA). However, during the workshop we decided to define primary compounds as those emitted at the source, whether in the gaseous or particulate phase, and that SOA should refer to aerosol formed by species that have experienced in-atmosphere chemical transformation. This is in part for practical reasons: in the absence of a defining chemical reaction, no molecular markers will be able to differentiate compounds emitted as gases versus those emitted as particles. The definition of SOA we've chosen therefore allows for more direct testing of source inventories against field data.

Organic aerosol classification

Organic aerosol has been classified in two ways: by *sources* (e.g., anthropogenic vs. biogenic) and by *properties* (e.g., black carbon vs. organic carbon; hygroscopic vs. hydrophilic, etc.). It was concluded that source classification is preferable, and that it is likely that the two categories will converge since organic aerosol from different sources tend to have distinct microphysical properties. These properties can be established through measurements, and a database should be built of distinguishing characteristics (chemical composition, optical properties, etc.) for organic aerosols from difference sources.

Source representation in models

Models that represent organic aerosols generally contain static inventories, but we know that sources of these aerosols will evolve with time and/or climatic changes, particularly where emissions are from biota sensitive to shifting temperature and precipitation regimes (Figure 6) or where biofuel consumption is expected to change. These feedback loops need to be incorporated in models. In addition, bottom-up estimates of the source strengths need to be tested using near-source in-situ measurements rather than with regional-scale measurements since ageing can dramatically affect aerosol concentrations and properties.

Partitioning of organic species

The fraction of atmospheric organic aerosol that was originally emitted in the gas phase is highly variable from location to location but is usually significant, especially over the continents (Figure 7). The formation pathways for these aerosol are also variable: organic gases can form new aerosols via nucleation or can be partitioned onto existing particles, either directly or via heterogeneous reactions. However, the details of each formation pathway and their relative importance is not well understood and the key species and controlling factors for partitioning from the gas to aerosol phase need to be identified.

Ageing & impacts on chemical and physical characteristics

The impact of ageing and cloud processing on organic aerosol and their mixing state with other aerosol components also is not well-constrained. The impact on aerosol hygroscopic properties are of particular interest because of both the effect on direct radiative forcing and the effect on the aerosols' efficiency as cloud condensation nuclei and ice nuclei.

Water uptake, CCN & IN

Field data show that organic aerosol hygroscopicity is highly variable with composition. Some studies have suggested that the presence of organics will suppress cloud droplet activation because of their low solubility. However, this depends on the fraction of the aerosol composition that is organic (for internally mixed particles), the chemical form of the organic, and the meteorological conditions. The very limited data available on organic aerosol as ice nuclei (IN) are inconclusive. Reduction of these uncertainties will require both laboratory and field measurements.

Composition & functional grouping

The chemical composition of organic aerosol is currently being measured using a range of techniques, including various forms of Mass Spectrometry (MS); Ion Chromatography (IC); Proton Nuclear Magnetic Resonance (HNMR); Infrared Spectroscopy (IR); NEXAFS/STX and TE and ETE Microscopy; and Evolved Gas Analysis (EGA). These measurement can provide highly detailed information about composition, but none allow for complete characterization of the complex organic species in the atmosphere. Since information on the complete molecular composition of particles containing organics is impossible with existing techniques and is unlikely to be realized in the foreseeable future, current strategies need to include both improvements to existing instrumentation and a method for characterizing organics using techniques that do not rely on full chemical speciation, such as functional groups. Simultaneously, existing measurement techniques should be exploited to characterize organic composition with property-based approaches.

Modeling organic aerosols, from CTMs to GCMs

Models are needed to integrate knowledge on organic species' sources, their transport, in-atmosphere aerosol formation, transformation, and properties (chemical, physical and optical) with the thermodynamics and meteorology of the ambient atmosphere in order to determine their effects on the biosphere and human health, their radiative impacts and, from that, their climate impacts. However, the complexity of the processes controlling atmospheric aerosol characteristics can only be captured using small-scale, high resolution models which are capable of simulating physical and chemical processes in great detail. Computational limitations do

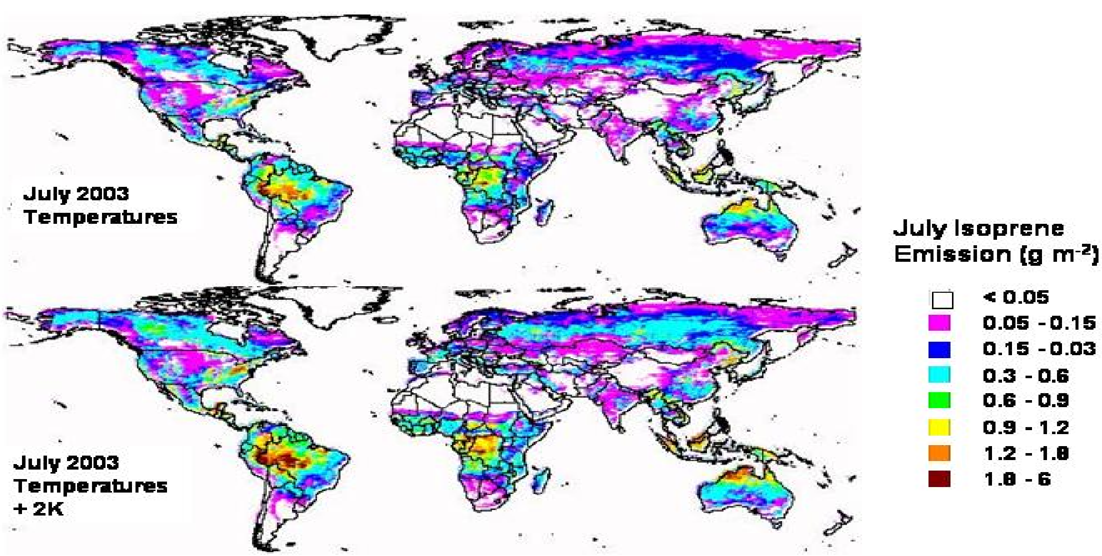

Figure 6 - Response of global isoprene emission rate distributions to a 2K increase in temperature. Emissions estimated by the MEGAN emission model (Guenther et al., submitted manuscript) for July 2003 (top) are compared with estimates where temperatures have been increased by 2K (bottom).

not allow this level of detail in global climate models (GCMs), so radiative and climate impacts must be determined using a hierarchy of models from regional to global scale. Thus, we need to identify which are the critical parameters for controlling OA formation and fate under both pristine and polluted conditions and identify suitable parameterisations of processes too complex to be included in full detail.

Interfacing measurements and models

Measurements are needed both as input to models and for model verification. In turn, models can be used to help guide measurements, such to define sensitive regions for integrated regional studies. In some cases measurements will not be able to provide the parameters desired as input (e.g. index of refraction) but nonetheless can be used to bound errors in these parameters (e.g. single scatter albedo). Model representation of the in-atmosphere formation of organic aerosols from gas species and the treatment of aerosol hygroscopicity in particular need to be improved and would benefit from measurements focussed on achieving this end. For example, rather than attempting full aerosol chemical characterization the focus should be on determining aerosol formation rates as a function of functional grouping. Laboratory measurements under controlled conditions will be essential to building the physically-based parameterizations needed to produce accurate representations of organic aerosol concentrations and properties.

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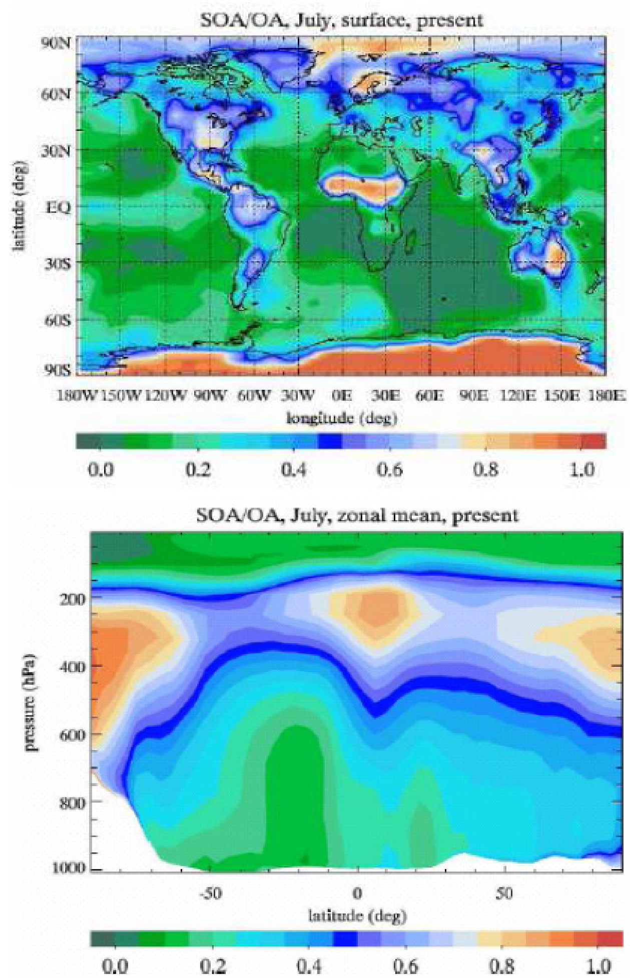

Figure 7 - The ratio of secondary to total organic aerosol at the surface (top) and the vertical profile of SOA/OA for the month of July (bottom). (Kanakidou et al., 2005).

ANNOUNCEMENTS

IGAC's 9th Open Science Conference, held jointly with CACGP and WMO September 17-23, 2006 Cape Town, South Africa

http://www.Atmosphericinterfaces2006.co.za

IGAC's 9th Open Science Conference will be held jointly with CACGP (the Commission on Atmospheric Chemistry and Global Pollution) and WMO (the World Meteorological Organization).

"Atmospheric Chemistry at the Interfaces", is the theme for the conference, which will highlight the current state of knowledge of the interaction between various components of the Global System. This theme represents the common interests of the three sponsors, and focuses on the great challenges of interdisciplinary research and effective cross-disciplinary communication in times of ever increasing specialization.

1st ACCENT Symposium
September 12-16, 2005
Urbino, Italy
http://www.accent-network.org/symposium/

The first ACCENT Symposium will be hosted in charming Urbino, Italy. The exceptional Renaissance urban complex of the town harmoniously adapted to its physical site offers a suggestive framework to this Conference which would be a prime tool to promote a common European strategy in the field of atmospheric composition change.

The three main aims of the Symposium are:
1. To review the latest scientific progress on the changing chemical climate of the European atmosphere
2. To provide a 'trade-fare' for various activities aimed at integrating atmospheric composition and chemistry research in Europe; and
3. To provide an opportunity for interaction among scientists, policy makers and general public.

1st iLEAPS Open Science Conference
January 21-26 2006
Boulder, Colorado, USA
http://www.atm.helsinki.fi/ILEAPS/boulder/

The iLEAPS Scientific Steering Committee invites you to participate in the 1st iLEAPS Open Science Conference.

The conference will highlight the relevant aspects concerning the interface between land-biosphere-atmosphere. In particular we will focus on four main topics:
- Land-atmosphere exchange of reactive and conservative compounds - key interactions and feedbacks in the earth system,
- feedbacks between land biota, aerosols and atmospheric composition in the climate system,
- feedbacks and teleconnections in the land surface-atmosphere-water-system, and
- transfer of material and energy in the soil/canopy/boundary-layer system: measurements & modeling.

2nd SOLAS Open Science Conference
March 6-9, 2007
Xiamen, China

SOLAS is very pleased to announce that the next SOLAS Open Science Conference will be held in Xiamen, China, following on from the successful meeting in Halifax in 2004. More details will be announced in due course.

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