IGACtivities NewsLetter
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In this Issue

A Note From the IGAC Chair

Guy Brasseur

The chemical composition of the atmosphere cannot be regarded simply as a mixture of gases. Liquid and solid aerosols are also present and play an important role in many respects. First, they interact with solar and terrestrial radiation and therefore affect the climate system significantly. The enhanced aerosol burden caused by human activities is believed to have slowed down (in industrial areas) the warming caused by increasing concentrations of greenhouse gases. Second, aerosols provide sites for heterogeneous reactions. It is now recognized that solid and liquid aerosols in the stratosphere activate anthropogenic chlorine, and therefore play a key role in stratospheric ozone depletion. Third, aerosols affect directly the formation of clouds in the stratosphere. Reactions occurring within cloud droplets could have an impact on the oxidizing capacity of the atmosphere. Finally, the deposition at the surface of liquid and solid aerosols has the potential to damage ecosystems.

To make further progress in our understanding of chemical processes in the atmosphere and to assess the consequences of human activities on climate, it is crucial to study chemical and physical processes which determine the formation and fate of the different types of aerosols in the atmosphere. This is why research focusing on aerosols has become a key priority for IGAC. I am therefore pleased to announce that under the leadership of Professors Peter Hobbs (University of Washington) and Barry Huebert (University of Hawaii), and with the collaboration of an international team of outstanding scientists, IGAC's *Focus on Atmospheric Aerosols* program plan has been completed and is now available from the IGAC Core Project Office. This plan will serve as a guide for a large number of scientific initiatives under the auspices of IGAC.

The present issue of IGAC*tivities* summarizes several IGAC efforts precisely related to aerosol research. Ongoing long-term studies and intensive measurement campaigns past and future are described.

Another important topic to be found in this issue is the announcement of the Conference on Global Measurement Systems for Atmospheric composition. The purpose of this international conference to be held May 20-22, 1997 in Toronto, Canada, is to address a major challenge for the atmospheric chemistry community: How most efficiently to use spacecraft, networks of ground stations, and chemical transport models to provide a global picture of the processes that affect chemical compounds in the troposphere and lower stratosphere. This conference is being co-organized by the WCRP project on Stratospheric Processes and Their Role in Climate (SPARC) and by the WMO Global Atmospheric Watch (GAW) and is being co-sponsored by several national and international space agencies. I hope to see you in Toronto.

GLOBAL CHANGE
IGBP

Introduction

IGAC Increases Emphasis on Atmospheric Aerosol Research

A. Pszenny, IGAC Core Project Office, USA

Aerosols are minor constituents of the atmosphere with relatively short lifetimes, diverse composition and high spatial variability in mass and number concentrations. Nevertheless they have important influences on human health (aero-allergic disorders), other aspects of air quality (visibility and acid deposition), and play a critical role in many weather and climate processes. Their climatic significance on a global scale has only recently been quantified: the first IPCC Scientific Assessment (1990) stated that "it is not easy to detemine the sign of changes in the planetary radiation budget due to aerosols", whereas the Second Assessment Report (1995) concluded that "anthropogenic aerosols tend to produce negative radiative forcing" (i.e., surface cooling effects) and that "locally, the aerosol forcing can be large enough to more than offset the positive forcing due to greenhouse gases".

In recognition of the need to better understand the roles of atmospheric aerosols in climate change, air quality, acid deposition, visibility reduction, and cloud and precipitation processes, an internationally coordinated program of research on atmospheric aerosols is urgently required. To this end, the International Global Atmospheric Chemistry (IGAC) Project and the International Global Aerosol Program (IGAP) have merged their ongoing efforts and plans into a new, integrated *Focus on Atmospheric Aerosols* (FAA) being carried out under the aegis of IGAC.

The initial primary goal of the FAA is to improve understanding of the role of atmospheric aerosols in the forcing mechanisms and prediction of change in global climate and in geospheric–biospheric processes. The FAA is comprised initially of four new IGAC Activities, which are primarily concerned with aerosols and their radiative effects:

- Aerosol Characterization and Process Studies (ACAPS)
- Direct Aerosol Radiative Forcing (DARF)
- Aerosol–Cloud Interactions (ACI)
- Stratospheric and Upper Tropospheric Aerosols (SUTA)

plus appropriate aspects of four ongoing IGAC Activities that include significant aerosol components: Marine Aerosol and Gas Exchange (MAGE), Biomass Burning Experiment: Impact on the Biosphere and Atmosphere (BIBEX), Polar Atmospheric and Snow Chemistry (PASC), and Global Integration and Modeling (GIM).

Under the general guidance of the IGAC Scientific Steering Committee (SSC), the FAA Activities will encourage and coordinate international research to accomplish their respective goals. When appropriate, FAA Activities will join together in combined research efforts to achieve complementary goals.

Examples of these combined efforts are the major field experiments (see Figure 1) that are underway within the FAA to study aerosol properties and processes, and to improve the descriptions of aerosols in global models:

- ACE-1 (November-December 1995) was conducted over the Southern Ocean, with a focus on natural aerosols produced from dimethylsulfide and sea spray.
- TARFOX (July 1996) was conducted off the east coast of the United States, with a focus on the direct radiative forcing of the anthropogenic aerosol plume advecting off the North American continent.
- ACE-2 (16 June - 25 July, 1997) will be conducted in eastern North Atlantic, with a focus on both the direct and indirect effect of anthropogenic aerosols from Europe and mineral dust from North Africa.

The FAA can play an important, perhaps a key, role in improving understanding of many issues related to atmospheric aerosols. To do so, however, will require the strong support of governments, and the unselfish endeavors of aerosol scientists worldwide.

A booklet describing the FAA was published recently by the IGAC Core Project Office. Copies are available on request.

This issue of IGAC*tivities* contains three articles about IGAC aerosol research in the North Atlantic region. The first one summarizes results from the Atmosphere/Ocean Chemistry Experiment (AEROCE), A long-term program that began nearly a decade ago–prior to the formation of IGAC–and is now a major component of IGAC's *North Atlantic Regional Experiment* (NARE) Activity. The second article is an initial report of the recently completed TARFOX field campaign. The third article outlines the plans for next year's ACE-2 campaign.

I wish to express my sincere appreciation to Joe Prospero, Phil Russell, Frank Raes, and their coauthors for providing these contributions.

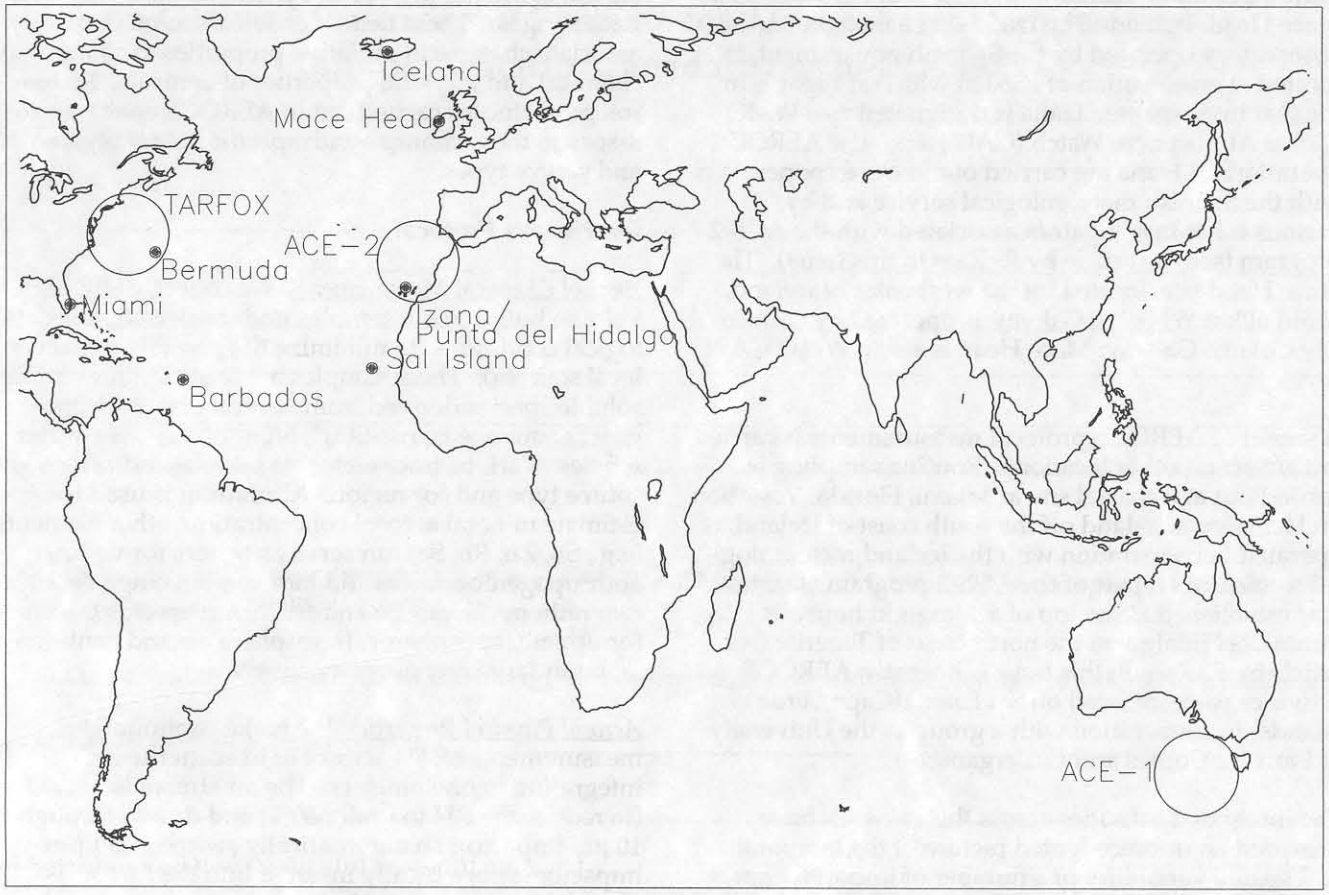

Figure 1. Locations of the ACE-1, TARFOX and ACE-2 experimental areas and the AEROCE measurement stations.

Features

The Atmosphere/Ocean Chemistry Experiment: AEROCE

Contributed by: J. M. Prospero, University of Miami (Florida), USA and S.G. Jennings, University College Galway, Ireland

Introduction

AEROCE is a comprehensive multi-disciplinary and multi-institutional research program that focuses on a number of aspects of the atmospheric chemistry over the North Atlantic Ocean. A major objective of AEROCE research is to gauge the impact of anthropogenic sources on the chemical and physical properties of the atmosphere, to assess the consequences of the perturbations on natural processes including climate, and, through the use of models, to predict the longer term effects. AEROCE Phase I began in September 1987; AEROCE is now in Phase III which will extend through 1998. AEROCE research is focused in two theme areas:

- *Theme 1:* Ozone and Oxidants: To understand the role of anthropogenic emissions and natural processes in the ozone budget and oxidizing capacity of the troposphere over the Atlantic.

- *Theme 2:* Aerosols and Climate: To characterize the chemical and physical properties of aerosols that are important to the radiative properties of the atmosphere and to climate; to study the processes that affect these properties; and to assess the relative importance of natural vs. human sources.

The AEROCE strategy is to develop a chemical climatology of the atmosphere over the Atlantic. This is accomplished with a coordinated protocol of continuous measurements of aerosol chemical and physical

properties in a network of stations: Barbados, West Indies; Bermuda; Izaña, Tenerife, Canary Islands; and Mace Head, Ireland. The Izaña site, a meteorological observatory operated by the Spanish government, is located at an elevation of 2360 m which at night is in the free troposphere. Izaña is designated as a WMO Global Atmosphere Watch (GAW) site. The AEROCE operations at Izaña are carried out in close cooperation with the Spanish meteorological service and by various other investigators associated with the ACE-2 program (see the article by F. Raes in this issue). The Mace Head site, located on the west coast of Ireland, about 60km WNW of Galway, is operated by University College Galway; Mace Head is also a WMO GAW site.

A subset of AEROCE protocol measurements is carried out at several other locations. Routine sampling is carried out at a coastal site at Miami, Florida. A station on Heimaey, an island off the south coast of Iceland, is operated in cooperation with the Iceland meteorological service. As a part of the ACE-2 program, a station was established at the top of a 40m light house at Punta del Hidalgo on the north coast of Tenerife (see article by F. Raes in this issue). Recently, AEROCE activities were initiated on Sal Island (Cape Verde Islands) in cooperation with a group at the University of Paris (L. Gomes and G. Bergametti).

The integrated activities across this network have provided an unprecedented picture of the temporal and spatial variability of a number of important gas, aerosol, and precipitation constituents across the entire North Atlantic. This report focuses solely on the Aerosols and Climate theme.

AEROCE Strategy for Assessing Aerosol Impacts on Climate

The AEROCE program follows two sampling strategies:

(1) a continuous sampling program that develops a climatological data set on the chemical, physical, and radiative characteristics of aerosols;

(2) intensive field programs that incorporate a much more detailed measurement protocol with a strong emphasis on aerosol size distribution measurements and radiative properties.

Long-term observations allow us to statistically characterize these properties and their temporal and spatial variability. Measurements taken during intensive field campaigns focus on specific processes in the context of case studies. In both modes, long-term and intensive, we test the completeness of our knowledge of aerosol properties by comparing the measured radiative parameters with those computed with aerosol radiative models. A major strength of AEROCE is that the sites are exposed to a wide variety of atmospheric conditions with winds that can carry aerosols from sources in North America, Europe and Africa; consequently, aerosol characteristics vary over wide ranges. These factors enable us to more readily associate changes in radiative properties to changes in chemical and physical properties of aerosols. Meteorological studies carried out in AEROCE enable us to associate these changes with specific source regions and source types.

Continuous Protocol

Aerosol Chemical Measurements We collect, daily, high volume bulk aerosol samples under selected meteorological conditions (to minimize the possible impact of local sources). These samples are analyzed for various soluble species derived from natural and anthropogenic sources, e.g., nss-$SO_4^=$, NO_3^-, NH_4^+, sea-water species. Various trace elements serve as indicators of source type and/or region. Aluminum is used to estimate mineral aerosol concentration; other elements (e.g., Sb, Zn, Rb, Se) can serve as tracers for various anthropogenic sources and biomass burning. Finally, two radionuclides, ^7Be and ^{210}Pb, are used as tracers for upper troposphere/stratosphere air and continental boundary layer air, respectively.

Aerosol Physical Properties We make continuous measurements of: (1) aerosol light scatter using integrating nephelometers. The air stream is heated (to reduce the RH to under 50%) and drawn through a 10 μm impactor; an automatically switchable 1 μm impactor is periodically inserted into the line so as obtain data that is specific to the large-particle and sub-micron size ranges; (2) aerosol composition in two size ranges: 1-10 μm diameter and the fraction below 1 μm (i.e., the same size fractions viewed by the nephelometer); (3) total aerosol number concentration; and (4) total aerosol light absorption coefficient using aethalometers operating in the green spectral range. The concentration of organic components and black carbon is estimated using a step-wise oxidation procedure and using non-dispersive IR measurement of the evolved CO_2.

Radiation measurements The sites at Barbados, Bermuda, Miami, Tenerife, and Sal Island currently make continuous radiation measurements with two types of instruments: rotating shadowband radiometers (RSR) and automatic solar-sky scanning radiometers (ASSR). The RSR measures radiation in 5 passbands and an open channel (for total downwelling irradiance), yielding diffuse, direct and total solar irradiance. This instrument is used extensively in the DOE/ARM program. The RSR's at the AEROCE sites are deployed by investigators from several different institutions. The ASSR (CIMEL) instruments automatically make direct sun measurements every 15 minutes at 340, 440, 670, 870, 940 and 1020 nm; sky radiance and polarization measurements are made hourly. The ASSR's are deployed by various groups but they are all integrated into the Aerosol Robotic Network (AERONET) under B. Holben (NASA, Goddard) who

maintains an on-line central data base for all instruments. Routine products are spectral aerosol optical depth, size distribution, phase function, asymmetry factor and precipitable water.

Other Measurements A variety of other measurements are made at AEROCE sites. These include continuous measurements of O_3 and CO. These data assist greatly in the interpretation of the aerosol data. In addition, meteorological data are obtained and meteorological support is provided (in the form of isentropic trajectories and other meteorological products) as a routine component of the AEROCE protocol.

Intensive Protocol

The aerosol intensives employ more sensitive aerosol aerosol/radiation instrumentation than that used in the continuous program. Emphasis is placed on measuring aerosol size distributions using state-of-the art instrumentation. Because many of these instruments have averaging times on the order of minutes, we obtain much higher temporal resolution which allows us to interpret changes in aerosol properties in terms of rapidly changing meteorological conditions. Consequently, specific aerosol properties can be more definitively associated with specific transport conditions.

Aerosol Physical Properties We continue to make the measurements listed in the Continuous Program (as listed above). In addition we measure: (1) aerosol total integrated light scattering and back scattering using a high-sensitivity integrating nephelometer (three spectral bands) that incorporates a back-scatter shutter (TSI Model 3563); and (2) aerosol size distributions with several instruments that cover the size range from 3nm to 15 μm diameter.

Aerosol Chemical Measurements In addition to the measurements that we make under the continuous protocol, we measure: (1) size distributions using a variety of impactors; (2) continuous total aerosol mass using tapered element oscillating microbalance; (3) annular diffusion denuders and filter packs.

During the past several years intensive field campaigns have been carried out at Bermuda, Barbados and Tenerife. In preparation for the ACE-2 campaign, we have participated in intensive field studies in cooperation with the Ispra group (see the article by F. Raes, this issue) during the summers of 1994 through 1996.

Some Examples of AEROCE Results

The measurements made over the past few years clearly show that the atmosphere over the North Atlantic is highly impacted by materials transported from continental sources. Table 1 presents the mean concentrations of some major aerosol species, based on at least several years of data. The concentrations of species such as non-sea-salt sulfate (nss-$SO_4^=$) and nitrate (NO_3^-) are substantially higher than concentrations in remote ocean regions (e.g., the southern oceans).

The effect of transport from North America is clearly evident at Bermuda (Figure 2) as reflected in the large day-to-day variability in the concentrations of NO_3^- and nss-$SO_4^=$. A seasonal pattern is also evident, with maximum concentrations in the winter and spring, when the region is often dominated by westerly flow. In contrast, during the summer, southerly winds are prevalent and the concentrations of NO_3^- and nss-$SO_4^=$ are subtantially lower.

Table 1. Concentrations of major aerosol constituents measured at AEROCE sites in the North Atlantic based on multi-year continuous sampling.

Station	Lat. °N	Long. °W	Al ng/m³	Dust⁺ μg/m³	NO_3^- μg/m³	nss-$SO_4^=$ μg/m³	NH_4^+ μg/m³
Mace Head	53.32	9.85	38	0.47	1.49	2.03	0.91
Bermuda	32.27	64.87	447	5.6	1.06	2.19	0.31
Izaña	28.30	16.50	1783	22.3	0.77	0.92	0.33
Miami			NA	5.6*	1.87	2.34	0.61
Barbados	13.17	59.43	1164	14.6	0.53	0.78	0.11

\+ Dust concentration computed from Al based on a crustal abundance of 8% except for Miami data which is based on weights of filter samples ashed at 500°C after extracting with water.

* Ash weight, 96 months of data.

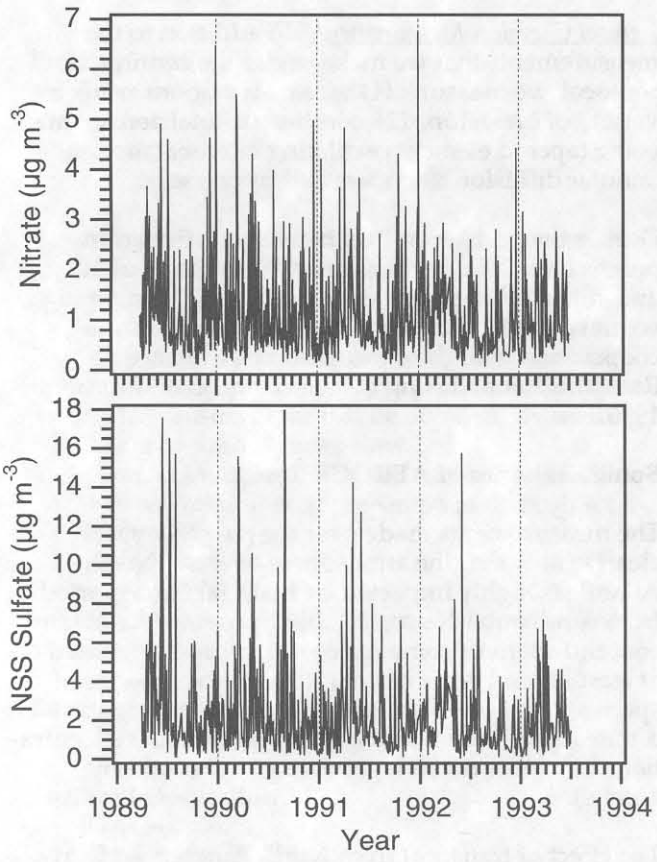

Figure 2. Aerosol concentrations on Bermuda, 1989-1993. Data are based on daily samples collected during on-shore winds. AEROCE maintains two sampling sites on Bermuda, one on the west end at Tudor Hill and one on the east end at David's Head. Thus, we can collect samples under all wind conditions. The data in the figure are composited from the samples collected at both sites. (Data courtesy of D. Savoie, Univ. of Miami).

One of the most striking features of the aerosol records at many AEROCE sites is the frequent presence of high concentrations of North African dust. As can be seen in Table 1, the concentrations of dust are quite high at Izaña and Barbados, but they are also substantial at Bermuda and Miami. There is a very clear seasonal cycle in dust transport (Figure 3), with maximum concentrations occurring in the summer at all sites. Note that the dust concentrations at Barbados are comparable to those measured at Izaña; although peak concentrations tend to be higher at Tenerife, the dust transport to Barbados occurs over a longer period during the year. Because of the more northerly location of Tenerife relative to Barbados, dust transport does not become persistent until mid-summer, generally in July. This feature has implications regarding the activities in ACE-2 which begins in mid-June and extends through July. According to the dust climatology of Tenerife, the ACE-2 region should be relatively dust-free in the early weeks and then dust levels should increase sharply.

The large variability of aerosol concentrations and properties at Izaña is illustrated in Figure 4 which shows data from July 1995. The air was extremely clean until mid July when there was a sudden influx of African dust. Note that the concentrations of all species increased sharply with the dust. Previous studies have shown that the nss-$SO_4^=$, NO_3^- and NH_4^+ associated with the dust was most likely derived from sources in Europe.

Summary

The AEROCE studies show that aerosols over the North Atlantic are greatly affected by transport from continental sources. The temporal and spatial variability of aerosols over this region is quite complex because of the abundance of sources, natural and

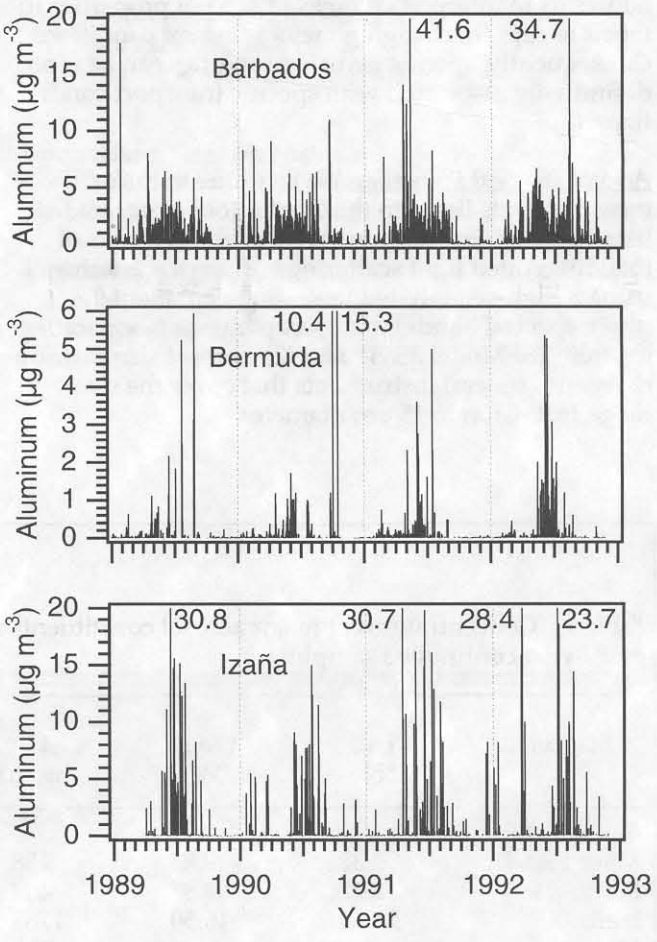

Figure 3. Daily aluminum concentrations in aerosols collected at Barbados,West Indies, Bermuda and Izaña Observatory. Samples are only collectedat night-time during downslope wind conditions. The mineral dust concentration can be estimated by multiplying the Al values by 12.5, assuming an average Al concentration of 8% in soils. (Data courtesy of R. Arimoto, Univ. of Rhode Island).

anthropogenic, that border the North Atlantic and because of the complex meteorology. Although we have developed some appreciation of the factors affecting aerosol concentrations over the Atlantic, we are far from a quantitative understanding of these processes. Our knowledge about the vertical distributions of aerosols is especially limited. Focused intensive field programs such as TARFOX and ACE-2 coupled with longer-term programs such as AEROCE will do much to improve our knowledge about these processes and the role that aerosols play in climate processes.

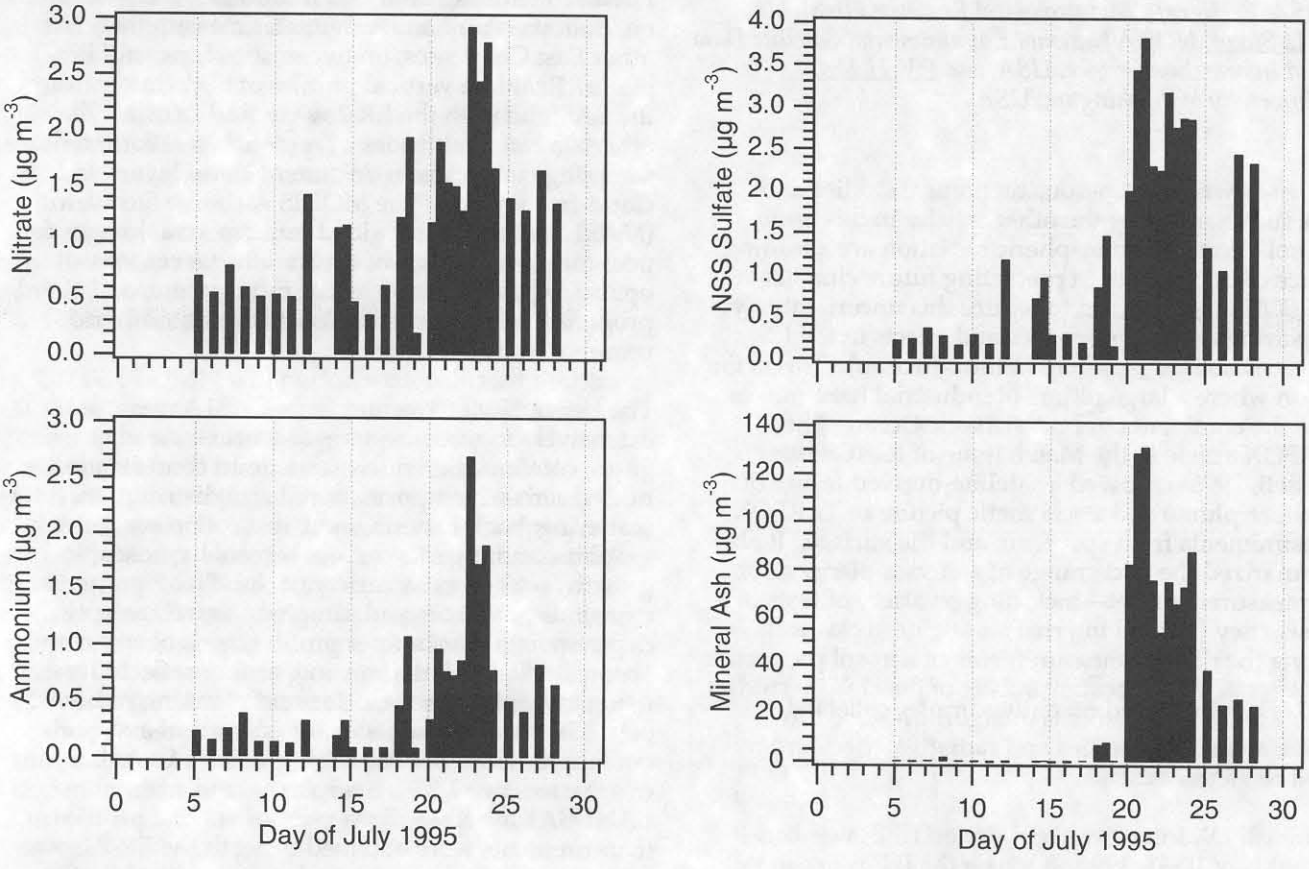

Figure 4. Daily aerosol concentrations at Izana Observatory, July 1995. Samples are normally collected only at nighttime during downslope wind conditions. During July, some daytime upslope sampling was done as well; these are also shown in the figure. The upslope wind concentrations do not appear to be substantially different from the nighttime samples, especially during dusty periods. (Data courtesyof D. Savoie, Univ. of Miami).

IGAC's *Tropospheric Aerosol Radiative Forcing Observational Experiment* (TARFOX) Field Program Completed

Contributed by: P.B. Russell, NASA Ames Research Center, USA, P. Hignett, Meteorological Research Flight, UK, L.L. Stowe, NOAA National Environmental Satellite Data and Information Service, USA, and P.V. Hobbs, University of Washington, USA

As shown by numerous theoretical studies and summarized by the other articles in this issue, aerosol effects on atmospheric radiation are a leading source of uncertainty in predicting future climate. TARFOX was designed to reduce this uncertainty by measuring aerosol properties and effects in the US eastern seaboard [see map in introduction]. This is the region where a large plume of industrial haze moves from the continent over the Atlantic Ocean. The TARFOX article in the March issue of IGACtivities (Russell, 1996a) showed a satellite-derived image of this haze plume and a schematic picture of TARFOX measurements from space, air, and the surface. It also summarized the wide range of analyses planned for the measurement set—including a variety of tests of consistency (termed internal and column closure) among the diverse measurements of aerosol properties and effects. An important subset of the closure studies is tests and improvements of algorithms used to derive aerosol properties and radiative effects from satellite measurements.

The TARFOX Intensive Field Period (IFP) was conducted July 10-31, 1996. Because the IFP was completed only a few months ago, the planned analyses are in their early stages. The purpose of this article is to summarize the measurements actually made and to give a brief indication of preliminary results. More detailed descriptions of operations and of analysis plans are in the TARFOX Operations Summary (Whiting et al., 1996), the recently published booklet describing IGAC's new aerosol research Focus (Hobbs et al., 1996), the TARFOX Science and Implementation Plan (Russell et al., 1996b), and on the WWW site http://prometheus.arc.nasa.gov/~tarfox/.

The TARFOX IFP included coordinated measurements from four satellites (GOES-8, NOAA-14, ERS-2, LANDSAT), four aircraft (ER-2, C-130, C-131, and a modified Cessna), land sites, and ships. A variety of aerosol conditions was sampled, ranging from relatively clean behind frontal passages to moderately polluted with aerosol optical depths exceeding 0.5 at mid-visible wavelengths. Spatial gradients of aerosol optical thickness were sampled to aid in separating aerosol effects from other radiative effects and to more tightly constrain closure tests.

Coordination of the four TARFOX aircraft was greatly aided by (1) near-realtime imagery of aerosols, clouds, and fog from the GOES-8 and NOAA-14 satellites, (2) special forecasts of the areas most likely to be cloud-free, and (3) forward and backward trajectory calculations. Aircraft flights were coordinated with overflights of the NOAA-14, ERS-2, and LANDSAT satellites, as well as with other times and locations of interest, including lidar and radiometer measurements on Wallops Island and radiometer measurements at other East Coast sites, on two cruise ships, and Bermuda. Realtime vertical profiles of backscatter from the LASE lidar on the ER-2 were used to direct the other aircraft to altitudes of aerosol layers for intensive sampling, as well as to document cloud layers and cloud-free regions. The MODIS Airborne Simulator (MAS) on the ER-2 provided multispectral images for post-mission analyses of ocean reflectance, aerosol optical depth and particle size information, and cloud properties. ER-2 cameras also documented cloud presence in study scenes.

The University of Washington's C-131A was used extensively to measure aerosol precursor and other gases, condensation nuclei and cloud condensation nuclei, aerosol composition and size distribution, total scattering, backscattering and absorption coefficients, graphitic and organic carbon, aerosol hygroscopic growth factors, and a variety of cloud/fog properties using *in situ* sensors and samplers, as well as optical depth spectra, backscatter profiles, aerosol and cloud absorption and scattering, and surface reflectivity using a sunphotometer, lidar, and scanning radiometer. The measurements included vertical and horizontal profiles beneath twelve NOAA-14 satellite overpasses, two ERS-2 overpasses, and one LANDSAT overpass. Seven sets of vertical profile measurements were obtained beneath the ER-2 (some with satellite overpasses), and seven vertical profiles above two sunphotometers and the Raman lidar at Wallops Island.

The United Kingdom Meteorological Research Flight C-130 measured radiances and hemispheric fluxes in selected wavelength bands from the ultraviolet through the infrared, total scatter, backscatter and absorption coefficients, aerosol and cloud particle size spectra, and aerosol chemical composition. The C-130 made several flights in good conditions for shortwave radiative flux measurements. Each flight included horizontal legs at typically ten altitudes with vertical profiles between the legs. The measurement periods coincided with overpasses of NOAA-14 and three were closely coordinated with the C-131. Profiles were also flown over the Wallops Island surface instruments.

The Pelican (a modified Cessna) of the Center for Interdisciplinary Remotely Piloted Aircraft Studies measured aerosol size spectra, and spectral radiances and radiative fluxes in a variety of spectral bandwidths. The Pelican made measurements at numerous altitudes up through the top of the main haze layer. Six

flights were flown under NOAA-14 overpasses and one flight was flown under an ERS-2 overpass. The Pelican flew in close coordination with the C-131A on three occasions during the final six flights. The first measurements with a new Ames tracking sunphotometer aboard the Pelican were collected during the final several flights of the Pelican in TARFOX.

At Wallops Island a Raman lidar measured vertical profiles of aerosol extinction and backscatter, and a variety of sun and sky radiometers measured optical depths and sky radiances used to derive scattering phase functions and aerosol size distributions. Two sunphotometers measured multiwavelength optical depth. Sun and sky radiometers were also operated at several other East Coast sites and Bermuda, as well as on cruise ships transiting between Bermuda and New York. Numerous aircraft flight legs and vertical profiles were flown over the surface sites to permit detailed intercomparisons. Other flight segments were devoted to intercomparisons among aircraft sensors.

A composite figure showing ER-2, C-131A, and Pelican flight paths in relation to a GOES-8 image of aerosol optical thickness (AOT), plus illustrative measurements by airborne and surface sensors, is included in Hobbs et al., 1996 for one TARFOX day, July 17, 1996. Here we show preliminary results regarding radiative forcing derived from the UK C-130.

Initial priority in the analysis of the UK C-130 data has been given to estimation of the shortwave aerosol forcing exemplified here simply by the change in downward solar flux arising from the presence of aerosol. The data available are measurements of the direct and diffuse components of the solar flux, over both the whole solar spectrum and the near-infrared, the difference thereby yielding the visible flux. A shortwave radiation code (Edwards and Slingo, 1996; Taylor et al., 1996), using the measured profiles of atmospheric temperature and humidity, has been used to define the aerosol-free state. This permits the calculation of an extinction optical depth defined over the visible wavelength range.

Missions carried out on the 26th and 27th July coincided with overpasses of the NOAA-14 and ERS-2 (on 27th) satellites. To gain a preliminary impression the data have been averaged over the length of the flight legs (approximately 60 km) and a plausible value of 0.7 assumed for the aerosol asymmetry parameter (this is required for corrections made during the diffuse flux measurements). The maximum visible vertical optical depth derived in this way was approximately 0.44 (on 27th). The results produced so far are summarized in Figure 5, where the change in downward solar flux (aerosol minus clear-sky) divided by the optical depth is plotted against the cosine of solar zenith angle. Around local noon on both days the aerosol induced change is about 100 W m^{-2} per unit optical depth. The numerous other data gathered will be similarly analyzed with more direct assessment of the aerosol optical properties and humidity growth, to permit a detailed comparison with radiative transfer codes.

The first TARFOX data workshop is scheduled for 29-31 January 1997. Preliminary results will be reviewed, and more complex integrated analyses (as described, e.g., by Russell, 1996) and presentations will be defined, with the overall goal of reducing uncertainties in the radiative forcing of climate.

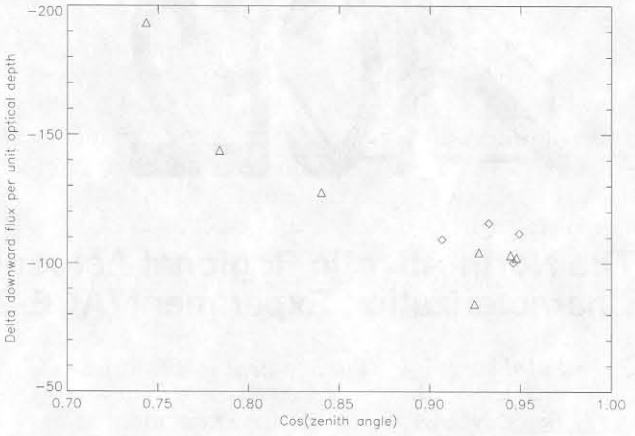

Figure 5. The change in downward solar flux (W m^{-2}) per unit visible optical depth versus cosine of solar zenith angle (diamonds for 26th July, triangles for 27th).

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The North Atlantic Regional Aerosol Characterization Experiment (ACE-2)

Contributed by: F. Raes, Environment Institute, Joint Research Center, European Commission, Italy, and T.S. Bates, NOAA Pacific Marine Environmental Laboratory, USA

Introduction

As noted elsewhere in this issue, ACE-2 is the third major experiment coordinated by IGAC that addresses the properties of the atmospheric aerosol relevant to radiative forcing and climate. The objectives of this series of experiments are to provide the necessary data to incorporate aerosols into global climate models and to reduce the overall uncertainty in the calculation of climate forcing by aerosols.

The ACE-2 Study Area

The ACE-2 study area is characterized by large scale subsidence, resulting in a distinct marine boundary layer (MBL) throughout the region. This MBL can be influenced by relatively clean maritime air from the open Atlantic or by anthropogenic pollution from Europe. The free troposphere (FT) aloft is influenced by clean mid-troposphere air or mineral dust from North Africa. The various air masses are well separated in time and space, which will offer an opportunity to compare and contrast the properties and controlling processes of the various aerosol types in the ACE-2 region with themselves and with those of ACE-1 and TARFOX. Preliminary results from two stations on the island of Tenerife illustrate the effect of the outbreaks of continental aerosol on relevant parameters such as the aerosol scattering coefficient and the number concentration of potential cloud condensation nuclei (Figures 6 and 7).

ACE-2 Scientific Goals and Experimental Approach

The goals of ACE-2 are to determine and understand the properties and controlling factors of the aerosol in the anthropogenically modified atmosphere of the North Atlantic and to assess their relevance for radiative forcing. To achieve these goals, ACE-2 will pursue three objectives:

- To determine the physical, chemical, radiative, and cloud nucleating properties of the major aerosol types in the North Atlantic region and to investigate the relationships between these properties,
- To quantify the physical and chemical processes controlling the evolution of the major aerosol types and, in particular, of their physical, chemical, radiative, and cloud nucleating properties, and
- To develop procedures for extrapolating aerosol properties and processes from local to regional and global scales, and to assess the regional direct and indirect radiative forcing by aerosols in the North Atlantic region.

Seven activities (CLEARCOLUMN, CLOUDY-COLUMN, LAGRAGIAN, HILLCLOUD, FREETROPE, LONGTERM, and INTEGMODEL) have been defined to focus the field campaign on these objectives. Each activity will address one or more of the following scientific questions using a number of different platforms (Figure 8).

- *Question 1*: Can the measured physical and chemical properties of the atmospheric aerosol be used to predict the radiative and cloud nucleating properties of that same aerosol?

This will be addressed by closure experiments on a number of ACE-2 platforms. Closure experiments produce an over determined set of observations such that the measured value of an aerosol property (e.g. scattering coefficient) can be compared to a value, calculated with an appropriate model (Mie theory) and based on independent measurements (aerosol size and chemical composition).

- *Question 2*: Are there useful empirical correlations between the mass concentration of individual aerosol components and the radiative and cloud nucleating properties of that same aerosol?

Although there are no physical reasons for such correlations to exist, they are presently the basis of the estimates of aerosol radiative forcing. The wide range of aerosol concentrations expected in the ACE-2 area will be used to test the range of applicability of these relationships.

- *Question 3*: Can the measured physical and chemical properties of the aerosol in the vertical be used to accurately predict the column-integrated direct effect of aerosols on radiative transfer?

Clear-sky column closure experiments (CLEARCOLUMN) will be a major activity of ACE-2. Lidars and sunphotometers at Sagres (Portugal), Tenerife, and onboard the ship will obtain vertical profiles of aerosol extinction and back scatter and total column optical depth. *In-situ* measurements from various aircraft and surface stations combined with airborne sunphotometer and satellite radiometers will be used to compare calculated and measured extinction in various aerosol layers.

CLEARCOLUMN thus revisits the questions addressed in TARFOX, but in an area where mineral dust plumes aloft can add one more degree of complexity.

- *Question 4*: Can the measured physical and chemical properties of aerosols and clouds in the vertical column be used to accurately predict the integrated indirect effect of aerosols on radiative transfer?

CLOUDYCOLUMN will perform coordinated flights with three aircraft. An aircraft below the MBL cloud will characterize the aerosol going into the cloud. A second aircraft will measure cloud microphysical properties and resulting radiation within the cloud, and a third aircraft will measure the radiative properties of the cloud as seen from above. The latter aircraft will carry a POLDER radiometer, similar to the one launched recently into orbit. The experiment will thus attempt to track, through the multitude of processes, the effect of aerosols on regional scale cloud albedo.

- *Questions 5 and 6*: What are the rates and efficiencies of the processes in the cloud free and cloudy MBL that change the number size distribution and size-dependent chemical composition of a continentally derived aerosol as it advects over the North Atlantic?

These process studies will use the Lagrangian observational framework developed in ASTEX/MAGE and ACE-1. LAGRANGIAN will follow, with one or more aircraft, a tagged air parcel from the Portuguese coast to somewhere south of Tenerife. The measurements will focus both on the fate of anthropogenic aerosols during transport and the effect of the aerosol on MBL cloud properties. LAGRANGIAN will be complemented by HILLCLOUD, which will operate on a more continuous basis, and will run three stations across the Taganana mountain ridge on Tenerife: one up-wind and below cloud, the second on the ridge within cloud, and the third down-wind and below cloud. In this way HILLCLOUD will study in detail the processing of gases and aerosols by a single cloud passage through the MBL cloud touching the ridge.

- *Question 7*: How do aerosols formed or transported in the free troposphere contribute to the direct radiative forcing over the North Atlantic, and how do they affect the properties of aerosols and clouds in the MBL?

FREETROPE will operate from the station at Izaña to characterize the aerosol in the FT, focusing in particular on mineral dust plumes from North Africa. In addition, one aircraft will be dedicated to study the formation and evolution of new aerosol particles in the subsidence area of the North Atlantic, the entrainment of these aerosols into the MBL and their effect on MBL aerosol and cloud dynamics.

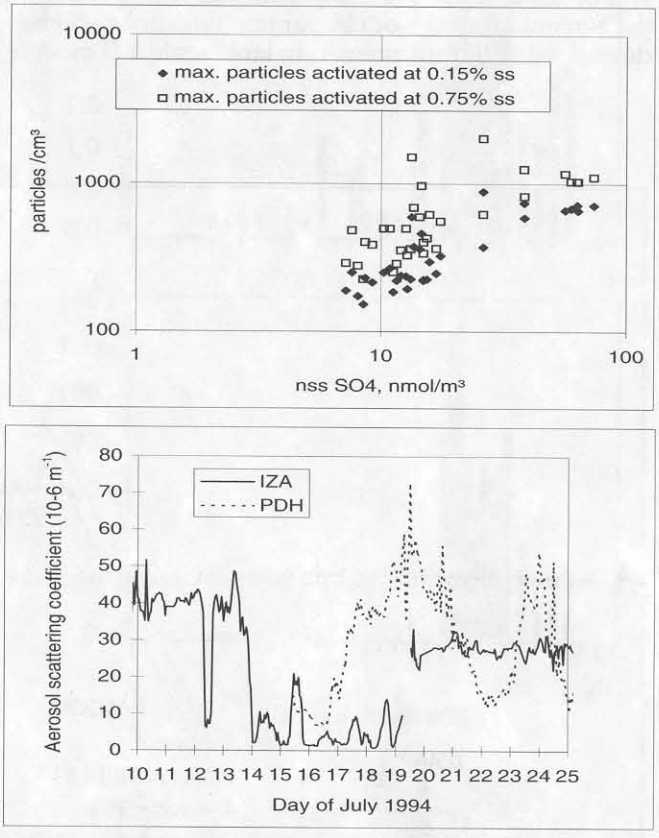

Figure 6. (top panel) Light scattering by aerosol particles at Punta del Hidalgo (MBL) and Izaña (FT), during July 1994. Two outbreaks of air from Europe resulted in a tenfold increase of the scattering coefficient in the MBL. In the FT, dust plumes from Africa resulted in equally high scattering coefficients. (Measurements from the Atmosphere/Ocean Chemistry Experiment, AEROCE).

Figure 7. (bottom panel) Potential cloud condensation nuclei as a function of non-sea-salt sulfate aerosol mass, at Punta del Hidalgo (MBL) during July 1995. (Potential CCN are obtained from aerosol size distribution measurements, considering those particles which would be activated between 0.15 and 0.75% supersaturation, assuming they were 100% ammonium sulfate). Clearly, there is a large potential of changing MBL cloud droplet concentrations with increasing anthropogenic impact in the area.

- *Question 8*: How can locally derived aerosol characteristics and process information be extrapolated to regional and global scales?

The measurements of the intensive ACE-2 campaign will be put in a climatogical context by comparing some of the key measurements with those obtained from the AEROCE and the ACE-2 monitoring network as part of the LONGTERM activity. The ACE-2 experimental phase will be followed by INTEGMODEL, a modeling activity in which radiation codes and process models will be tested against the experimental results. Based on the aerosol process models, parameterizations will be developed and implemented in large scale 3-D models of the North Atlantic region.

ACE-2 Schedule

ACE-2 will take place from 16 June to 25 July 1997. A data workshop will be held in the spring of 1998 at the JRC-Ispra to begin integrating the data sets. The initial results from the experiment will be presented at the 5th IGAC Scientific Conference in Seattle, Washington (USA), in August 1998.

Detailed information on ACE-2 can be found on http://www.ei.jrc.it/ace2/or by email from ace2office@ei.jrc.it

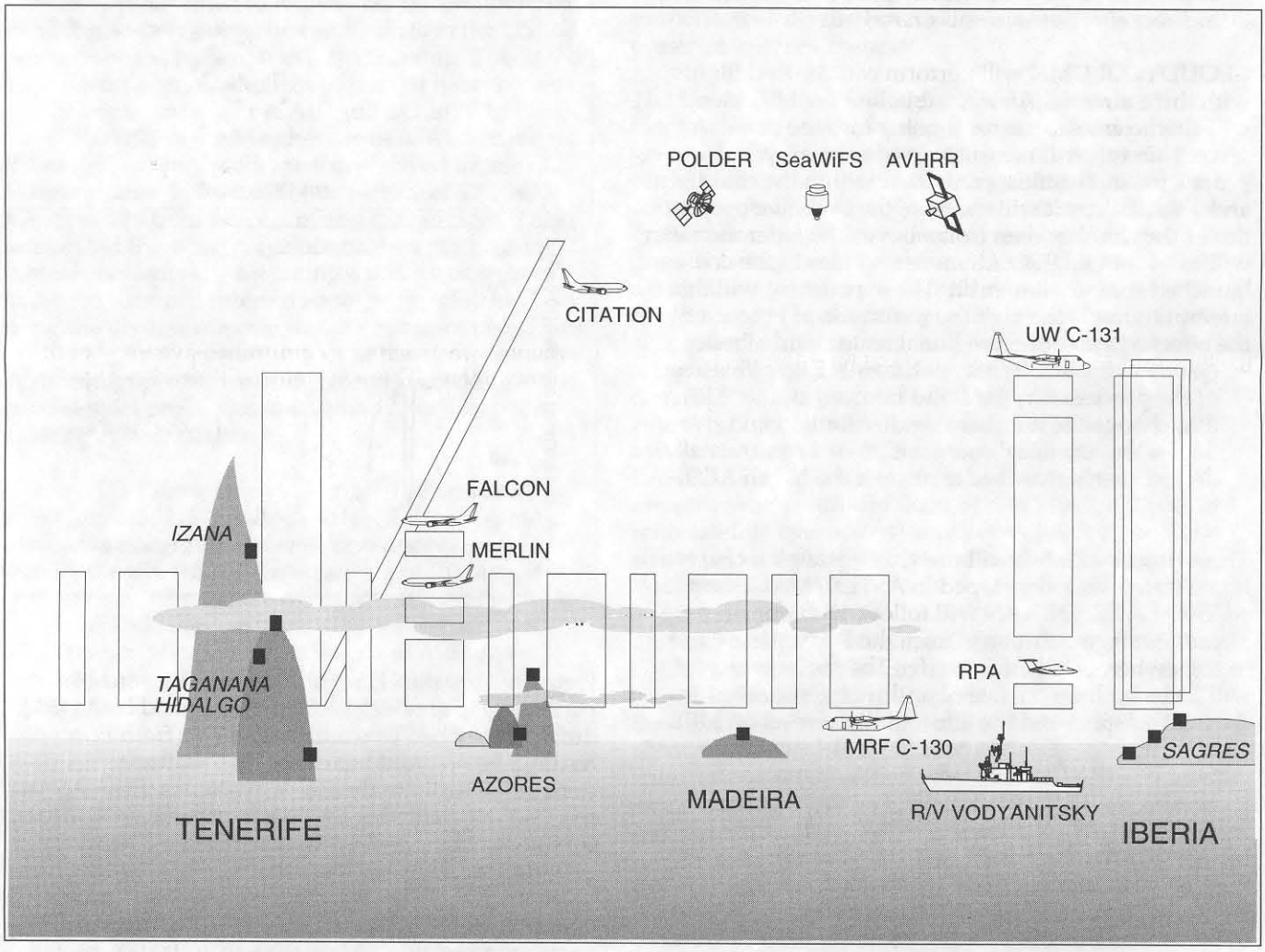

Figure 8. ACE-2 data will be collected from several aircraft [MRF C-130 (UK), Merlin IV (France), Falcon 20 (Germany), Citation II (Netherlands), UW CV-580 (USA, decision pending), CIRPAS RPA Pelican (USA, decision pending)], ground stations [Izaña, Taganana, and Punta del Hidalgo (Tenerife (Spain)); Sagres, San Miguel (Azores), Porto Santo (Madeira) (Portugal)], satellites [POLDER, SeaWiFS, AVHRR] and a ship [R/V *Vodyanitsky* (Institute of Biology of Southern Seas, Sebastopol, Ukrania)].

Announcements

IGAC/SPARC/GAW Conference on Global Measurement Systems for Atmospheric Composition

Toronto, Ontario, Canada. May 20-22, 1997

INTRODUCTION

The realization that the chemical composition of the atmosphere is changing on a global scale has far reaching implications for the health of the environment and the future of human society. This leads to a requirement that many nations participate in assessing the current state and trends of the chemical state of the atmosphere. This requires in turn the assembly of global measurement systems for atmospheric composition.

The aim of this conference is to bring together managers, scientists and policy makers to discuss current knowledge of and predictive capabilities for atmospheric composition, to define the near-term requirements for global measurement systems, and to begin developing a framework for more comprehensive systems in the future.

Background for the discussions will be provided by invited papers from leaders in the field from around the world as well as contributed papers on all of the associated topics.

This conference is intended to stimulate interaction between three groups of people: those who plan and conduct large space-based experiments, those who are involved in other large scale measurement programs both as planners and experimenters, and modelers. The conference format will be designed to facilitate discussion and exploration of synergistic opportunities through invited presentations, contributed papers, and opportunities for discussion and feedback.

PRELIMINARY LIST OF TOPICS

Space-based measurements

- Are being planned by several countries and have great potential for global measurements. These systems have the capability for great coverage, but also have some specific limitations.
- Ground-based networks are an essential part of any comprehensive measurement system.

Upper Atmosphere Measurements

- Many years of progress in upper atmospheric measurements have created a tremendous wealth of information about this region.
- New challenges continue in the areas of monitoring and the success of international agreements on emission control.

Lower Atmosphere Measurements

- This area of the atmosphere is just being opened up to space-borne measurements which will supplement a long history of measurements by other techniques. The heterogeneous nature of the region and the complexity of the interactions with the surface make this a very challenging area of expansion.

Calibration and Validation

- These are essential parts of a comprehensive measurement program maintained over any long period of time. The "honesty" of a measurement system and the disentaglement of artifacts from real events require continual assessment and vigilance.

Modeling

- Is an essential element in a system where not all parameters can be measured at all times. The diagnostic and predictive properties of the models are extremely important to our deep understanding of the global atmospheric system.

Data Assimilation

- Complements the models and assists the measurements, constructing a comprehensive view of the atmosphere. These systems will need expansion and refinement as our desire for knowledge increase.

Policy Issues

- It is apparent that selection of objectives will be required due to limitation on funding, and priorities will need to be set based on requirements from both the scientific community and society as a whole.

Future Requirements and Possibilities

- As we look to the future there are always new possibilities and new things to consider.

PRACTICAL INFORMATION

Conference Dates

- The conference will be held on May 20-22, 1997.

Conference Location

- The conference will be held in the **Holiday Inn on King** hotel in downtown Toronto, Ontario, Canada, adjacent to the University of Toronto campus. Toronto is directly accessible from North America, Europe and Asia and is served by a modern international airport.
- The Holiday Inn is situated about 0.5 km from the city center in the heart of the theater district.

(continued)

Pre-Registration
- Form on opposite page.

Abstracts
- Abstracts will be due on March 1, 1997.

- Abstract submittal will be by electronic means wherever possible. For further information on electronic submission, please see below. Where electronic submission is impossible, authors are requested to prepare a one-page abstract on 8.5" by 11" or A4 paper using 12 point or larger type.
- Further instructions can be obtained by mailing or faxing to the address below.
- Abstracts will be publicized on the World-Wide Web as well as being presented in an abstract volume.

Proceedings
- The conference proceedings will be published shortly after the meeting

Language
- The conference language will be English.

Further Information

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IGAC *tivities* Newsletter

Editor, Alex Pszenny; Layout and Proofing, Elaine Robbins; Logos by Linda Kubrick

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IGAC/SPARC/GAW Conference on Global Measurement Systems for Atmospheric Composition Toronto, Ontario, Canada. May 20-22, 1997

Pre-Registration

Name_____

Institution_____

Address _____

Phone_____

Fax _____

e-mail_____

__ I wish to attend the IGAC/SPARC Conference on Global Measurement Systems for Atmospheric Composition, and to receive additional information.

__ I am unsure at this time whether I can attend the conference, but would like to receive additional information.

__ I intend to present a paper entitled: _____

_____

_____

Please return this form to:

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Fourth IGAC Scientific Conference

UPDATE

The **Fourth IGAC Scientific Conference** will consist of three CACGP co-sponsored symposia at the 1997 joint Assemblies of the International Association of Meteorology and Atmospheric Sciences (IAMAS) and International Association for Physical Sciences of the Ocean (IAPSO) to be held in Melbourne, Australia, from 1-9 July 1997. Outlines of the symposia were published in the previous issue of IGAC*tivities* and are available on the IGAC web page (http://eb.mit.edu/igac/www/). Here we repeat their titles and Convener contact information and provide some additional information on Symposium IM22 which is also being co-sponsored by the IGBP's Global Change and Terrestrial Ecosystems (GCTE) Core Project.

Symposium JMP3: Chemical Processes and Climate

1. Aerosol Controls on Climate. *Convener: Barry Huebert, Department of Oceanography, University of Hawaii, Honolulu, HI, USA (email: huebert@soest.hawaii.edu); Co-Convener: John Gras, CSIRO Division of Atmospheric Research, Aspendale, Vic., Australia (email: john.gras@dar.csiro.au).*
2. Air/sea Exchange of Particles and Gases. *Co-Conveners: Peter Liss, School of Environmental Sciences, University of East Anglia, Norwich, UK (email: p.liss@uea.ac.uk) and Robert Duce, Dean, College of Geosciences & Maritime Studies, Texas A&M University, College Station, TX, USA (email: rduce@ocean.tamu.edu).*
3. Ozone as a Greenhouse Gas. *Convener: Roseanne Diab, University of Natal, Dalbridge, South Africa (email: diab@mtb.und.ac.za); Co-Convener: Ian Galbally, CSIRO Division of Atmospheric Research, Aspendale, Vic., Australia (email: ian.galbally@dar.csiro.au).*

Symposium IM7: Tropospheric Chemistry and Related Air/Surface Exchange in Polar Regions

Convener: Greg Ayers, Division of Atmospheric Research, CSIRO, Aspendale, Vic., Australia (email: greg.ayers@dar.csiro.au. Co-Conveners: Martin Manning, National Institute of Water and Atmospheric Research, Lower Hutt, New Zealand (email: manning@gaia.grace.cri.nz); Leonard Barrie, Atmospheric Environment Service, Downsview, ON, Canada (email: lbarrie@dow.on.doe.ca) and Robert Delmas, Lab. de Glaciologie et Geophysique de l'Environnement, St. Martin d'Hères, France (email: delmas@glaciog.grenet.fr).

Symposium IM22: Closing the Budgets of CO_2, CH_4 and N_2O

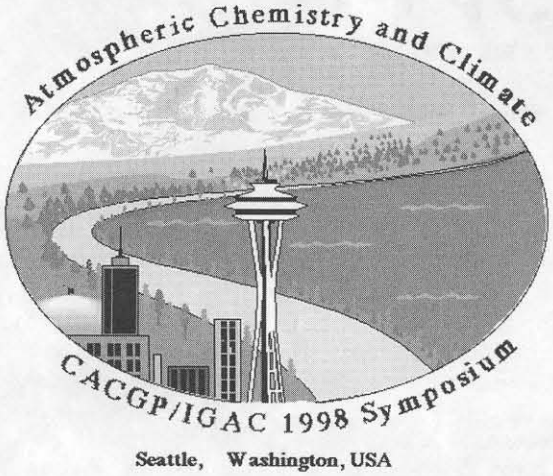
Convener: Paul Fraser, CSIRO Division of Atmospheric Research, Aspendale, Vic., Australia (email: paul.fraser@dar.csiro.au); Co-Conveners: Mary Scholes (IGAC), University of the Witwatersrand, South Africa (email: mary@gecko.biol.wits.ac.za), and Robert Scholes (GCTE), CSIR Forest Science and Technology, Pretoria, South Africa (email: bob@csir.co.za).

The topics that will be examined during this symposium include: (1) The ocean and the terrestrial biosphere as sinks for CO_2, (2) Natural sources of CH_4 from wetlands, and (3) N_2O emissions from terrestrial systems. Special emphases will be on: (a) Determination of regional source and sink strengths by direct measurement or by inverse methods using atmospheric and oceanic observations; (b) Ecological controls on production, sequestration, and destruction of these long-lived radiatively active species within terrestrial ecosystems; and (c) Decade-to-century time scale changes in ecosystems due to climate and other changes, and the influences of these changes on trace gas emissions.

This Symposium will be of particular interest to GCTE and IGAC collaborators. The objective of the Symposium is to bring together terrestrial, oceanic and atmospheric trace gas scientists to synthesize the current state of knowledge regarding missing sources and sinks of the major long-lived greenhouse gases: CO_2, CH_4 and N_2O. The global budgets for all the gases are imperfectly balanced, meaning that the sum of the known sinks is not equal to the known sources plus the change in atmospheric concentrations. The approaches to "closing the budgets" which will be discussed include inverse modelling of atmospheric concentrations, isotopes, and detailed budgetary exercises. The evidence for and against various proposed missing sources and sinks will be presented and discussed.

Joint International Symposium on Global Atmospheric Chemistry

UPDATE



Ninth Symposium of the IAMAS Commission on Atmospheric Chemistry & Global Pollution (CACGP)

and

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

Seattle, Washington, USA
19-25 August 1998

The First Announcement of this Symposium appeared in the previous issue of IGAC*tivities*. For further information, contact:

Dr. Patricia Quinn
CACGP/IGAC Meeting - 1998
NOAA/PMEL/OCRD
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Email: quinn@pmel.noaa.gov

Or access the Symposium web site at
http://saga.pmel.noaa.gov/cacgp98/.

Important Note:

The 1998 American Meteorological Society Conference on Cloud Physics is currently planned for the Seattle area from August 17-21, 1998. The conference is timed to partially overlap the CACGP-IGAC Symposium on Global Atmospheric Chemistry. Cloud and Precipitation chemistry sessions at the Cloud Physics Conference will be scheduled on 17-18 August so that scientists interested in these disciplines can attend both the AMS and CACGP-IGAC conferences. Information about the Cloud Physics conference can be obtained from the Program Chairman, Dr. Bob Rauber (r-rauber@uiuc.edu), or by accessing the conference web site at:

http://www.atmos.uiuc.edu/cloud_phys_conf/