IMPLEMENTATION PLAN

March 1996

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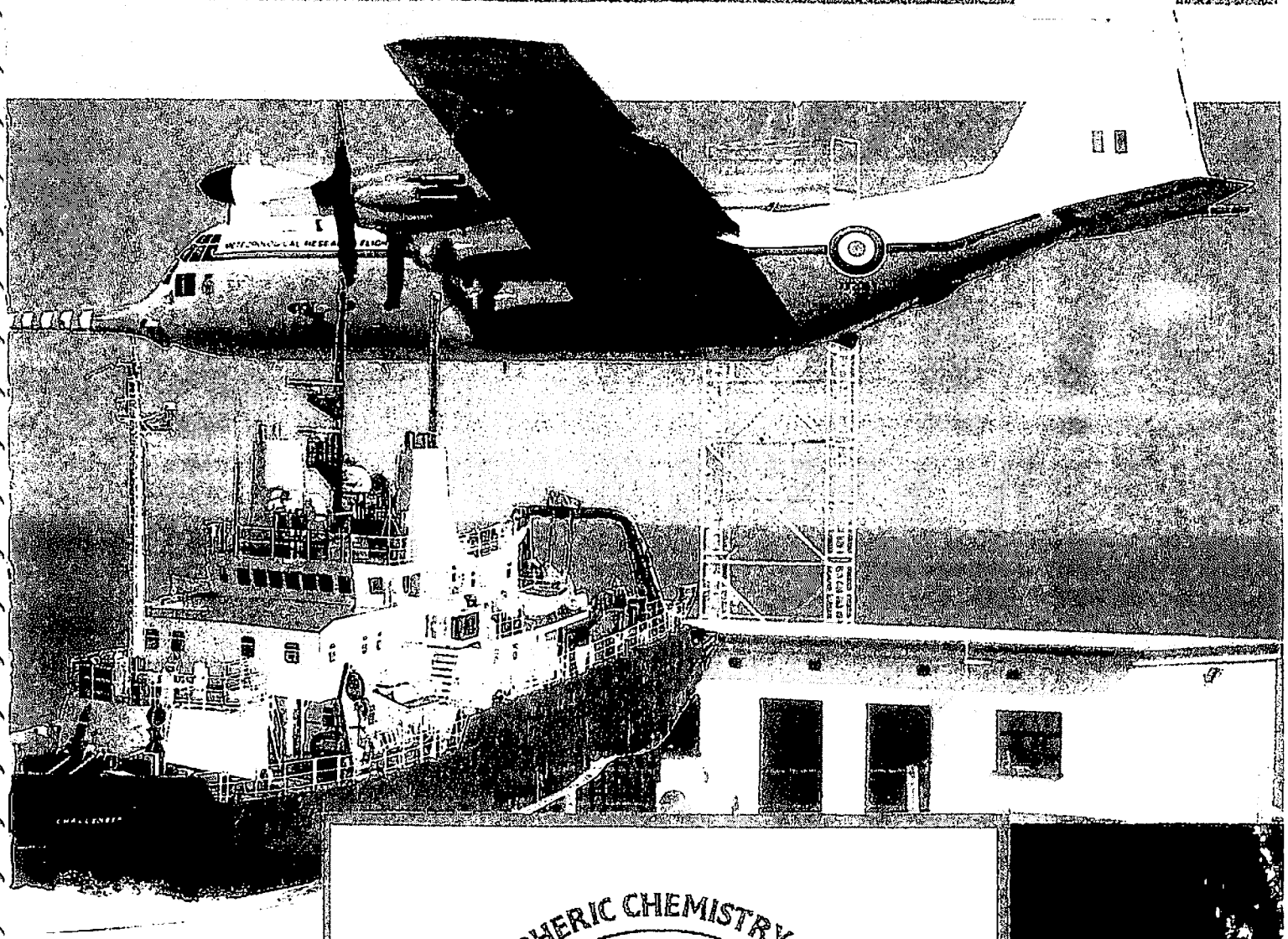
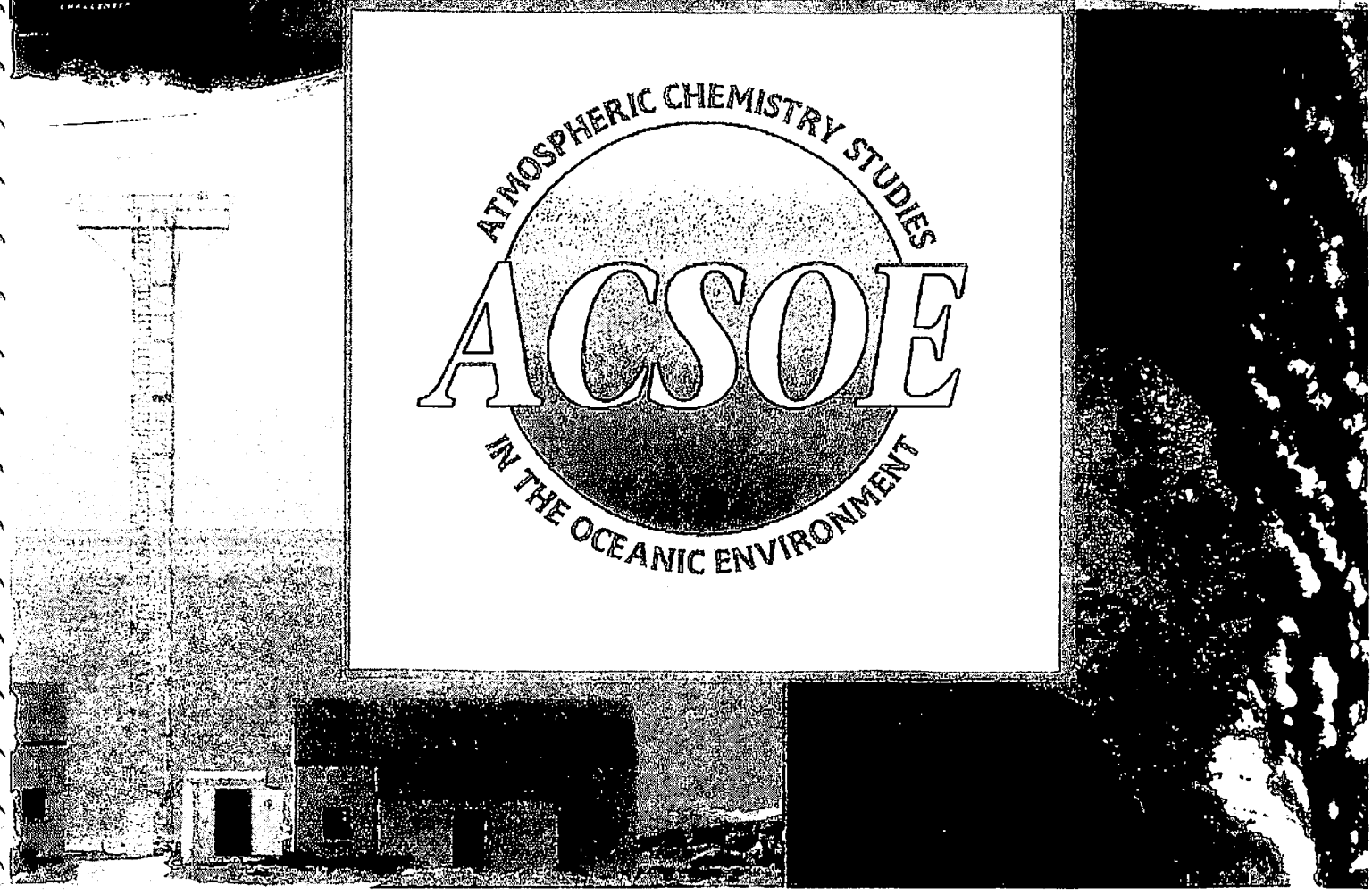


ATMOSPHERIC CHEMISTRY STUDIES

ACSOE

IN THE OCEANIC ENVIRONMENT



ATMOSPHERIC CHEMISTRY STUDIES IN THE OCEANIC ENVIRONMENT (ACSOE)

A UK Community Research Programme of the Natural Environment Research Council

IMPLEMENTATION PLAN

March 1996

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FOREWORD

This document follows on from the ACSOE Science Plan, released in December 1994, and should be read in conjunction with that document. The Science Plan states the intended aims, objectives and background science for ACSOE. In the intervening period, funding for ACSOE has come on line, and the Core Group and management structure have been established. Two Special Topic Award rounds have taken place: one for the main experimental phases of ACSOE, and one for supporting data interpretation and modelling studies. In addition numerous meetings have taken place of the ACSOE Review Group, the Core Group, and the individual Consortia, culminating in the "All-ACSOE" Meeting at the University of East Anglia, 11-13 December 1995, attended by some sixty participants.

As a result of this latter meeting, and with the aid of a set of proformas completed during and after the meeting, the precise objectives of ACSOE have been defined, and plans formulated for achieving them. A writing group meeting was subsequently convened at the Blakeney Hotel, Norfolk, 5-7 February 1996, attended by key Core and Consortium members, and representatives of the data and modelling communities - the Executive Editors of this document - with the aim of compiling this information into the Implementation Plan presented here. The draft Plan was produced in February 1996, and was approved by the ACSOE Science Steering Group in March 1996.

The Executive Editors wish to thank all ACSOE participants for their invaluable input to the various meetings and questionnaires which have gone into the Implementation Plan.

The Implementation Plan will also be available in electronic form via the ACSOE Home Web Page at address http://www.uea.ac.uk/~e011/acsoe/acsoe.html. Bulletins and updates will also be available from this page, along with general information on ACSOE.

Front Cover: Some of the major platforms to be used in ACSOE Campaigns. Clockwise from top: MRF C-130 Hercules; UEA Weybourne Atmospheric Observatory; Satellite image of northern Tenerife showing cap clouds and marine stratocumulus; UCG Mace Head Observatory; and RRS Challenger. The Cranfield Jetstream and RRS Discovery are not shown.

EXECUTIVE SUMMARY

Atmospheric Chemistry Studies in the Oceanic Environment (ACSOE) is a five-year Community Research Programme to investigate the physico-chemical processes occurring in the atmosphere (the boundary layer and the free troposphere) over the oceans. These studies aim to both bring about a clearer understanding of natural processes in the remote marine atmosphere, and the modification of these processes by the presence of anthropogenic emissions. Such studies are vital in understanding regional- and global-scale changes in atmospheric chemistry and climate. Particular emphasis will be placed on studies of the complex photochemistry of ozone and other oxidants (the "oxidising capacity") in the marine atmosphere, and on the evolution and modification of aerosols and cloud condensation nuclei. Both of these aspects have a major influence on the Earth's atmospheric radiation balance; both directly in the case of clouds, aerosols and ozone, and indirectly in the case of atmospheric oxidation processes. These latter processes control the lifetimes of many "greenhouse" gases. The basic science underlying ACSOE is discussed in more detail in the ACSOE Science Plan published in December 1994. The ACSOE Implementation Plan provides detail of the means by which the experiments which constitute ACSOE will be carried out.

The study area for ACSOE will stretch from cold water regions south of Iceland, through temperate ocean regions (notably the eastern Atlantic and North Sea), to the subtropical Atlantic (notably on and in the region of the Canary Islands). Experiments will be conducted from airborne, ship, and ground-based platforms, including the MRF C-130, Cranfield Jetstream, RVS Challenger, RVS Discovery, and ground stations at Mace Head (Ireland), Weybourne (Norfolk), and five altitudinal sites on Tenerife. Much of the data will be gathered during major field campaigns in the spring and summers of 1996, 1997 and 1998. In addition, long-term measurements and seasonal cycles will be investigated. Pivotal to the interpretation of this immense amount of data will be a suite of modelling studies. To facilitate these interpretation studies, and to allow the dissemination of the data (including eventual public access), all ACSOE measurements will be collated, organised and placed on line by the British Atmospheric Data Centre (BADC) at the Rutherford Appleton Laboratory.

The operation of ACSOE is undertaken jointly by an ACSOE Core Group, located primarily at the University of East Anglia, and by three Consortia of UK Institutes and Universities funded through the ACSOE Special Topic Awards. The Core Group comprises a Programme Manager, Data Manager, ship and aircraft Facilitators and associated researchers. The Core Group provides the essential support, logistic, and management underpinning of the programme, together with many of the key measurements required in ACSOE experiments.

The three Consortia comprise OXICOA (OXIdising Capacity of the Ocean Atmosphere), MAGE (Marine Aerosol and Gas Exchange), and ACE (Aerosol Characterisation Experiment). OXICOA is a study of oxidant, radical and related gas-phase chemistry in the clean and moderately polluted marine atmosphere. MAGE is a study of aspects of air-sea exchange relevant to atmospheric chemistry and aerosol production. ACE will study the processing of gases and aerosols through hill cap clouds on Tenerife and sub-tropical marine stratocumulus. Many of these activities are closely linked to major European and International programmes such as ACE-2, TACIA, and ASGAMAGE.

ACSOE experiments will lead to the development of new or improved analytical techniques, the comprehensive instrumentation of the C-130 aircraft, and the implementation of some of the largest combined air-sea-ground studies of atmospheric chemistry in the UK. It also heralds a new level of co-operation between atmospheric chemists, aerosol/cloud physicists, oceanographers, and modellers. This degree of integration of disparate disciplines is a key feature of the programme.

Most importantly, ACSOE activities will provide a wealth of readily accessible data on the chemical state of the Atlantic and North Sea atmosphere, together with new insights into the processes therein. This will be of vital importance to regulatory and policy-making bodies who must manage and maintain atmospheric air quality and the impacts of climate change in this region.

CONTENTS

APPENDICES

ATMOSPHERIC CHEMISTRY STUDIES IN THE OCEANIC ENVIRONMENT (ACSOE)

IMPLEMENTATION PLAN

1. INTRODUCTION

1.1 Background

Two of the most significant environmental challenges of the day, to scientists and policymakers alike, are global climate change and global atmospheric chemical change resulting from man's activities. Climate change brings the threat of sea level rises, impacts on agricultural capacity and natural flora and fauna, desertification, extreme weather, extinction of species, and so on. Global chemical change is exemplified by the apparent doubling of background tropospheric ozone levels since the beginning of the 19th century. Ozone is harmful to human health, to crops and vegetation, and is itself an important greenhouse gas. Ozone production and loss processes form part of a larger, complex chemistry; a chemistry which is highly dependent on the presence or absence of even small amounts of anthropogenic emissions of hydrocarbons and oxides of nitrogen. An important parameter is the "oxidising capacity" of the atmosphere which, simplistically, reflects the ability of the atmosphere to 'cleanse' itself of many pollutants and greenhouse gases.

Aims and objectives of ACSOE:

The ACSOE programme has two main strategic aims:

(1) To investigate the underlying chemical processes responsible for controlling the concentration of many trace gases in the troposphere; otherwise known as the oxidising capacity; in particular, to quantify the perturbations which have taken place to the major oxidising species: ozone, peroxides and free radicals, as a result of anthropogenic emissions of many trace gases.

(2) To investigate the production of CN and aerosols from oceanic and terrestrial emissions of gaseous sulphur compounds, and its direct and indirect impacts on the radiative balance in the troposphere.

Whereas greenhouse gases provide the direct radiative forcing component of climate change, aerosols and clouds form the dominant moderating term, and are also the most complex and least well understood part of the system. Aerosols and cloud condensation nuclei may both originate, and/or be modified, by the ocean and by pollution sources. Furthermore, their chemical evolution may be affected by the same complex photochemical chemistry of which the "oxidising capacity" chemistry is also a part.

ACSOE is an NERC-funded programme focused specifically on understanding the physico-chemical processes occurring in the troposphere over the oceans, remote from strong anthropogenic sources; particularly those processes that produce ozone and aerosols. The ACSOE programme provides the opportunity for the UK atmospheric chemistry community to perform field experiments of direct relevance to climate forcing, which are necessary to understand individual chemical processes before their inclusion in global climate models. The main region of interest will be the North Atlantic Ocean and its surrounding shores, where the interactions between man-made pollutants transported from the continents and the natural substances emitted from the ocean can be studied. ACSOE will be imple-

mented through a series of large-scale field campaigns involving multicomponent measurements of atmospheric composition in well-defined meteorological regimes. These observations will be complemented by selected longer-term measurements which will provide information on seasonal and shorter-term variability. When combined into a common database, the observations will enable the testing of theory based on process studies, and ensure its correct incorporation into numerical models. ACSOE will therefore require measurements to be collected semi-continuously at strategically situated ground-based atmospheric observatories in conjunction with a similar set of measurements to be made in coordinated campaigns by ships and aircraft. The data collected in these experiments will be interpreted by theoretical models of differing complexity.

1.2 Consortia and Components

The ACSOE experimental programme (Figure 1.1) is divided between three consortia, with overall coordination by the ACSOE Core Group (cf. Section 8). The Oxidising Capacity of the Oceanic Atmosphere (OXICOA) is principally a study of oxidant, radical and related chemistry in the clean and moderately polluted marine troposphere. The Marine Aerosol and Gas Experiment (MAGE) is a study of those aspects of air-sea exchange relevant to atmospheric chemistry and aerosol production. The Aerosol Characterisation Experiment (ACE) will study the processing of gases and aerosols through hill cap clouds and marine stratocumulus in the region of Tenerife. The Consortia activities (cf. Sections 2-4) are subdivided into suites of "Experiments" conducted at various ground stations, and from airborne and shipboard platforms. The official repository for ACSOE data is the British Atmospheric Data Centre (BADC). The BADC will work closely with the Core Group and ACSOE Investigators not only in the collection of data, but also in providing 'value-added' products from ACSOE data, and in supplying ancillary data (such as meteorological products) for planning purposes (Section 6). Modelling activities will form an integral part of ACSOE, in experiment planning, for 'on-the-fly' data interpretation during field campaigns, and for post-campaign interpretation and modelling studies (Section 5). Model output data will be stored at BADC along with the observational measurements. Numerous linkages exist with other international programmes (Figure 1.1) which provide a considerably broadened scope for the ACSOE programme (cf. Section 10).

1.3 Infrastructure and Resources

Infrastructure support is provided through the ACSOE Core Group, based largely at the University of East Anglia (cf. Section 8). The Core Group provides overall scientific direction to the programme; hosts planning, logistical and scientific meetings; oversees the flow of data to BADC; provides logistical support through its Facilitators; manages the main ACSOE finances; and ensures liaison both within ACSOE and to NERC. The experimental work will be carried out by the Core Group and, importantly, the various Institutes funded through the ACSOE Special Topic Programme, and the ACSOE Modelling and Data Interpretation Programme (Appendix A.4). Of considerable importance to the programme will be the research platforms (Section 7): notably the MRF C-130 Hercules Research aircraft, NERC vessels (principally Challenger and Discovery), and ground stations at Mace Head, Ireland; Weyboune, Norfolk; and five sites on Tenerife. Access to the C-130 is co-ordinated by NERC's Atmospheric Research Airborne Support Facility (ARASF). Additional aircraft support, notably for Mace Head campaigns, will be provided by the Cranfield Jetstream aircraft, accessed through the Atmospheric Chemistry Research Unit of Imperial College, London. The Mace Head site is owned and managed by the University College, Galway, who will also collaborate with the scientific objectives of ACSOE. The Weybourne Observatory is owned and managed by UEA. The division of funding between the components of ACSOE is illustrated in Appendix A.8.

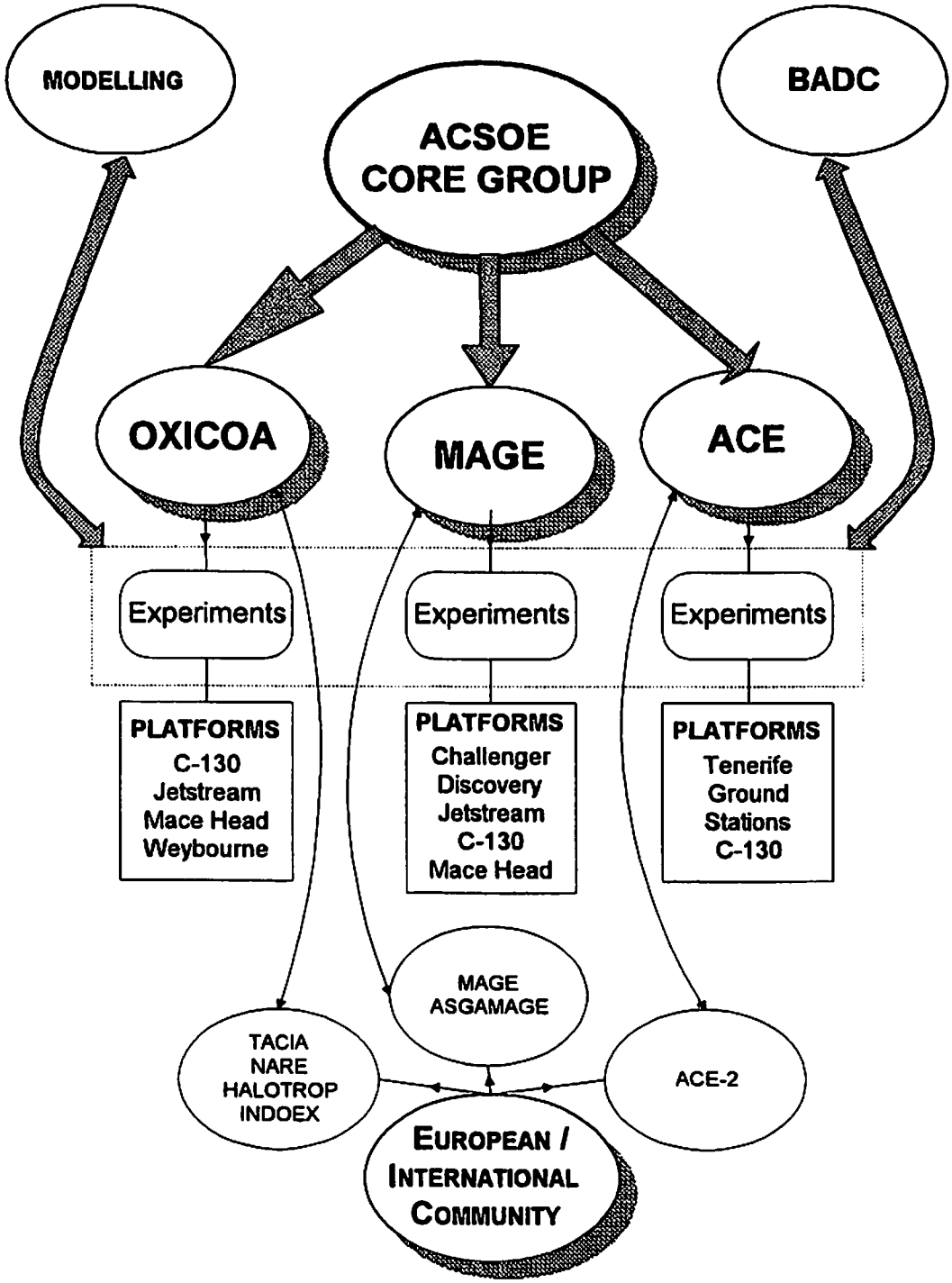


Figure 1.1 Components of ACSOE and Key International Linkages

1.4 Implementation

The objectives of ACSOE will be achieved through a series of field campaigns and integrated modelling and data interpretation studies. The time scale for these activities is shown in Figure 1.2. ACSOE officially began in January 1995. The first year's activities were largely concerned with the setting up of the Core Group and Consortia, with the two Special Topic Award rounds (for field measurements and modelling/data studies, respectively), and with a series of planning meetings and platform orientation visits. Field campaigns begin in the spring of 1996, and continue through until late 1998. Not shown on the timeline are seasonal/individual experiments and continuous/semi-continuous

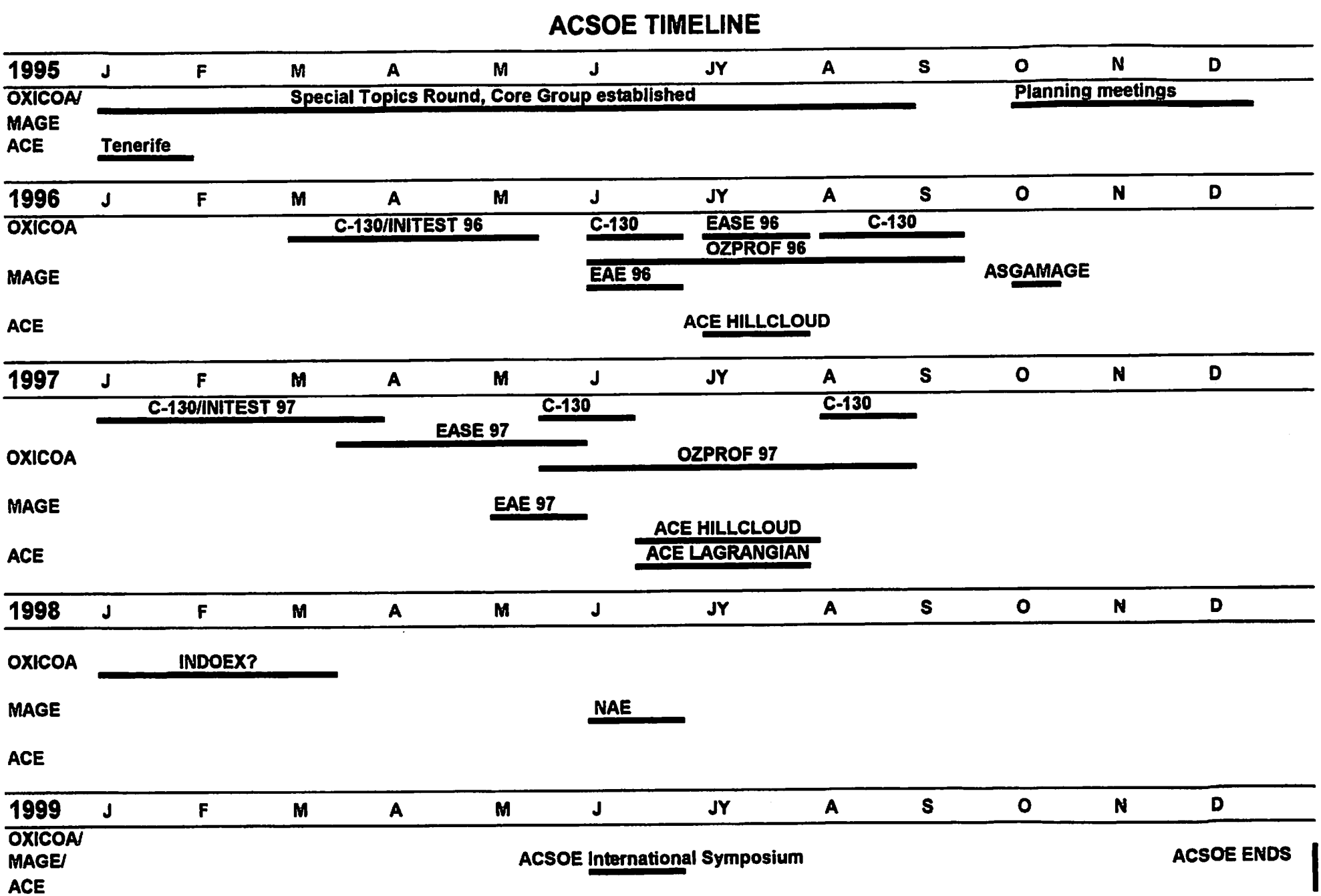


Figure 1.2 Timeline for major ACSOE Campaigns

measurements. An example of the former would be AMCHEX; studies of air mass chemistry throughout the year using the C-130 aircraft, comprising individual flights outside of campaign periods. An example of the latter is the continuous baseline measurements being collected at Mace Head. Activities in 1998 have yet to be fully planned and, at the time of writing, are more-or-less speculative. Outline details are presented in the Implementation Plan for these activities, but Update Bulletins will be issued regarding these experiments in due course. .Most of the Special Topic Awards will have expired by the end of 1998, but the ACSOE Core will continue through 1999. Activities in 1999 will be mostly centred around data studies, data validation and assembly of the completed database, together with writing assignments.

The geographical extent of ACSOE is illustrated in Figure 1.3. Ground bases are identified, as well as the locations of some of the experiments. In some instances the experiment locations can be quite exactly described, such as the hill cloud experiments on Tenerife. In others, such as C-130 experiments, the location will depend, for example, on the position of boundaries between air masses, and might be encountered over wide latitudinal and longitudinal ranges. Concentric rings show the range of the C-130 versus transit time from Boscombe Down. C-130 experiments could take place anywhere within the outer range, or further still if refuelled or deployed to other bases. Some representative examples of air mass tracks that may be followed in some of the Lagrangian-type experiments are also shown by open arrows, but these are by no means a complete illustration of all possibilities. In the wider context, the opportunity exists to compare the North Atlantic and North Sea studies that comprise the major research effort of ACSOE, with experiments in the Indian Ocean atmosphere, in the clean Southern Ocean atmosphere, and with 'historical' atmospheres trapped in snow and ice.

1.5 Products

An understanding of the composition of the marine atmosphere is vital in assessing the effects of man-made pollutants on the chemistry of the global atmosphere, and the impact - via oxidant chemistry and aerosol production/modification - on global climate. ACSOE should yield new insights into the physico-chemical processes that drive the atmospheric chemistry of the oceanic atmosphere. It will, further, provide the data required to both evaluate the present extent of the anthropogenic perturbation of the natural system, and to predict the response to changing emissions from man-made sources. A large database will be assembled on the atmospheric chemistry over the Atlantic, North Sea and wider areas. This will comprise observational data from aircraft, ship and ground stations, from both intensive field campaigns and year-round 'climatological' measurements. It will also, importantly, contain model output data from a variety of modelling and data interpretation studies. The observational data will be invaluable in the validation of modelled chemical and aerosol fields and in the development of chemistry parameterisations. With this in mind the ACSOE model studies will be carried out in association with the Hadley Centre, UGAMP and DoE funded Atmospheric Chemistry Modelling programmes, thus contributing to the science of climate prediction. It is aimed to thoroughly document and disseminate the knowledge gained from the ACSOE experiments through numerous publications in scientific journals, through seminars and symposia, through the release of CD-ROMs containing highlight data, and by opening up the entire database to public access by the end of 2000.

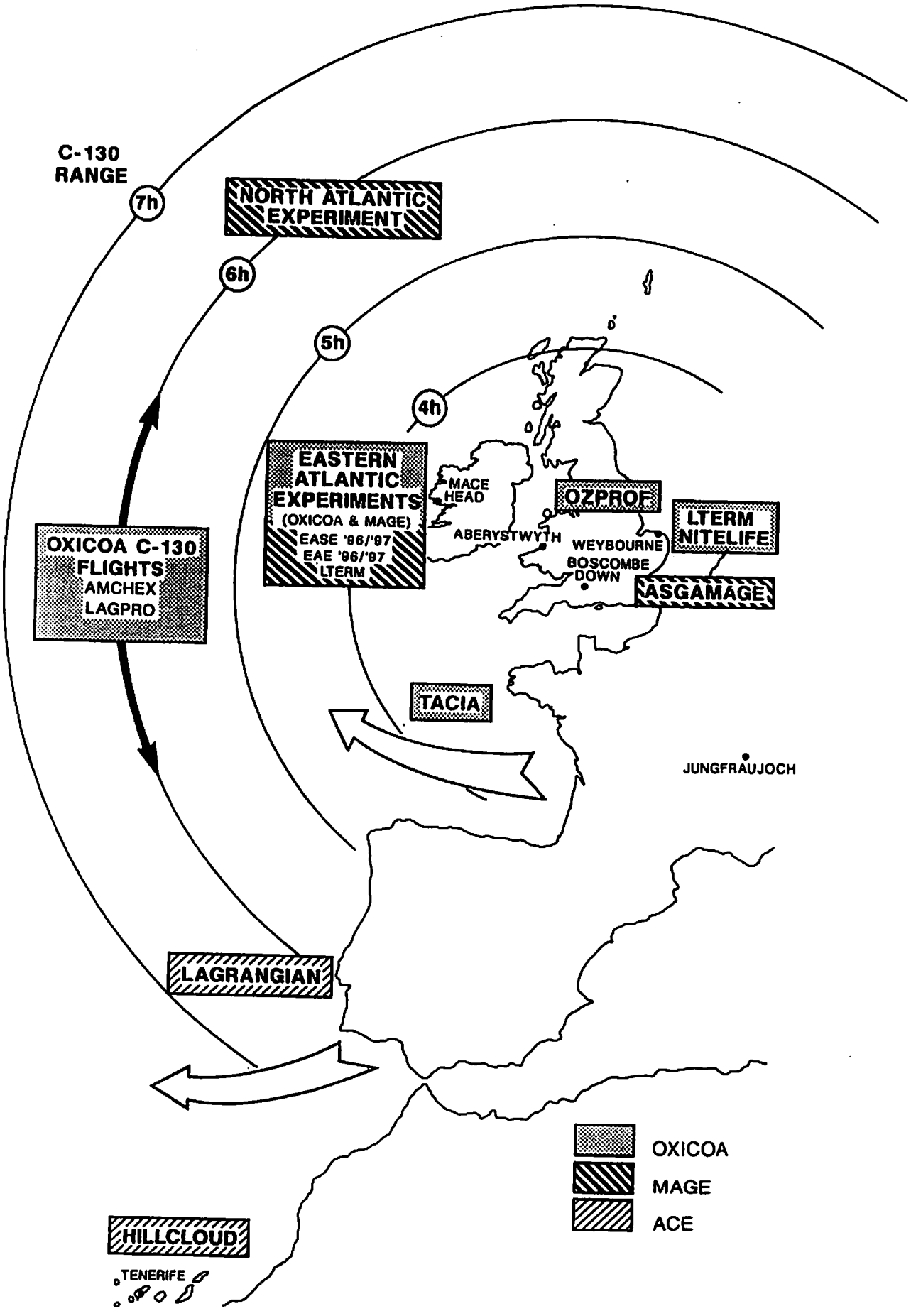


Figure 1.3 Location of Major ACSOE Experiments

Main Products of ACSOE Research

- Improved understanding of oxidation processes and aerosol formation/modification processes in the background atmosphere and the role of the oceans in regulating climatologically-important gases and aerosols.
- A comprehensive assessment of the natural chemistry of the oceanic atmosphere, and its perturbation by man-made emissions - notably with respect to ozone, aerosols, and clouds.
- Parameterisation of these sources, sinks and processes for input into global climate models.
- Extensive database of atmospheric chemistry and associated measurements: available to the public domain (Internet and CD-ROM).
- Development and deployment of state-of-the-art analytical instruments, including the comprehensive instrumentation of a large research aircraft for simultaneous and *in situ* fast-response measurements of atmospheric chemistry.

Innovations within ACSOE

- Integration of studies between disparate disciplines: atmospheric chemistry, chemical oceanography, and cloud/aerosol physics.
- First major NERC programme linking measurement campaigns by large research aircraft, ships, and ground stations.
- First NERC-funded dedicated atmospheric chemistry flights on the MRF C-130.
- Some of the largest atmospheric chemistry field campaigns ever mounted by UK scientists.
- Integration with major European/International projects such as ACE-2, TACIA and ASGAMAGE.
- Deployment of ground-breaking and powerful new instruments, including:
  - ◊ ultra-high sensitivity, fast response NO, NO_y, NO_x aircraft instrument
  - ◊ first airborne peroxy radical amplifier instrument (PERCA)
  - ◊ vertical-sounding DOAS for NO_3 measurements
  - ◊ FAGE instrument for direct OH and HO_2 measurements
- Integration of modelling studies throughout all ACSOE activities, from campaign planning to data interpretation.

2. OXICOA: OXIDISING CAPACITY OF THE OCEANIC ATMOSPHERE

2.1 Introduction

The OXICOA component of ACSOE will study various aspects of the oxidising capacity of the atmosphere concerned with tropospheric ozone, with HO_x and RO_x chemistry, with nitrate radical chemistry and with halogen chemistry. The ACSOE Science Plan (December 1994) discusses these individual topics in some detail. Outline summaries are given below and these lead to a set of four main objectives for OXICOA (see separate box).

OXICOA Objectives

(I) A study of the tropospheric ozone budget in clean and moderately polluted atmospheres throughout the year and particularly in the spring months.

(II) A study of HO_x and RO_x chemistry and its impact on stable oxidant production and trace gas equilibrium concentration.

(III) A study of NO_3 chemistry in clean air conditions through the troposphere.

(IV) To seek evidence for the presence or absence of an extensive halogen atom chemistry.

2.1.1 Tropospheric Ozone Budget

There is evidence that over the past fifty years or so the ozone concentration has increased throughout large parts of the troposphere in the Northern Hemisphere. Old data records of varying reliability suggest that ozone levels in the last century in Europe were less than half the levels currently existing. Recent data records also show an increase over some continents but the situation over the remote oceans is not well documented and is currently unclear. Whereas it is very likely that ozone has increased throughout the whole Northern Hemisphere north of the tropics due to emission of pollutants, this remains to be proven in a comprehensive study of the factors contributing to ozone production and loss in the troposphere.

Within Objective (I) it is proposed to:

- Calculate ozone production and loss rates and compare with measurements.
- Use a comparison of measured and calculated peroxide profiles as a diagnostic for regions of ozone production and loss at different seasons in different air masses.
- Determine the relative efficiency of peroxide and ozone production at different NO_x levels.
- Determine NO_y speciation and its correlation with ozone.
- Look for contrasts in these correlations between tropospheric and stratospheric air.
- Determine CO/ozone, HCHO/ozone and peroxide/ozone correlations in different air masses.

- With the aid of models use the data to estimate the amount of ozone produced and destroyed by tropospheric photochemistry over the North Atlantic Ocean and elsewhere.

2.1.2 HO_x and RO_x Chemistry

Current theory predicts that the chemistry of the HO_x species (OH and HO_2) and the organic RO_x species (RO_2 and RO) plays a central role in the determination of the oxidising capacity of the troposphere. This chemistry is highly coupled with the chemistry of ozone and the NO_x species, and just as with ozone it is possible that it may have been perturbed by emissions of gases from human activities.

Within objective (II) it is proposed to:

- Calculate [OH] for comparison with direct measurements.
- Determine [OH] indirectly from changes in HC ratios and HNO_3 production.
- Check the validity of RO_2 calculated from the modified Leighton expression.
- Quantify the sources of peroxy radicals.
- Quantify the relative efficiency of ozone, HCHO and HONO photolysis as sources of radicals.
- Determine the sensitivity of [OH] to the different components of its formation and removal processes in different air masses and at different seasons.
- Use the data and its analysis to validate models of tropospheric chemistry.

2.1.3 NO_3 Chemistry

The nitrate radical, NO_3, formed from the reaction of NO_2 with ozone, is a potentially important oxidising radical. During the day it cannot accumulate, owing to its rapid photodissociation and reaction with NO. At night, or at low light levels, when NO_x is mainly in the form of NO_2 and NO is absent, its reactions with a large number of organic compounds (eg. DMS, aldehydes, alkenes) may represent significant sinks for these compounds, under conditions when the concentration of OH is significantly suppressed. Observations of the ratios of branched-chain and straight-chain hydrocarbons over the North Atlantic in winter show a completely different value to that present on emission, and provide strong indirect evidence for large NO_3 concentrations in 'clean' Atlantic air.

Within objective (III) it is proposed to:

- Measure NO_3 radical concentrations at ground level and in the free troposphere.
- Determine the variation of $t(NO_3)$ with height.
- Compare $t(NO_3)$ with its value determined from the concentrations of reactive substrates.
- Determine the contribution of NO_3 chemistry to the production of nitrates.
- Use DOAS measurements of other molecules in intercomparison studies with other measurement techniques
- Use the data to validate models to be used to determine the impact of NO_3 chemistry on the trace gas composition of the troposphere.

2.1.4 Halogen Chemistry

The potential impact of the halogens on the oxidising capacity of the troposphere occurs primarily as a result of their influence on the concentration of ozone. For example, the observation of surface ozone

depletion at marine locations for a range of latitudes has often been interpreted in terms of the chemistry of the halogens, particularly bromine. On the other hand, both chlorine (Cl) and bromine (Br) atoms may initiate the oxidation of organic compounds leading to the generation of HO_x and RO_x and therefore, depending on the level of NO_x, either ozone production or removal.

Within objective (IV) it is proposed to :

- Make DOAS measurements of ClO, BrO and IO radicals.
- Look for various possible iodine, bromine and chlorine source gases.
- Relate ozone depletion events to atmospheric hydrocarbon composition
- Make estimates of the impact of halogen radical chemistry on the trace gas composition of the troposphere.

2.2 OXICOA Facilities and Experiments

Many experiments carried out within OXICOA will utilise the C-130 Hercules aircraft operated by the Met Research Flight. This aircraft will be equipped with state-of-the-art instrumentation for measurements of many trace gases and other chemical and physical quantities, many of them new installations especially for ACSOE. The Hercules experiments include the Airmass Characterisation Experiments (AMCHEX), Lagrangian and Chemical Processing Studies (LAGPRO), and NITELIFE, which is a vertical profile study of NO_3 lifetimes. The extent to which all of the experiments described here can be investigated will depend critically on available flying time, the occurrence of suitable conditions, and the ability to achieve several objectives in individual flights. It is estimated that a minimum of 65 hours per year of C-130 time is required (in addition to externally-funded projects) to meet the basic scientific aims of OXICOA aircraft experiments.

A second major component of OXICOA experiments will be ground-based campaigns carried out at Mace Head which will focus on the full diurnal cycles of stable oxidants and free radicals and their behaviour with respect to the photodissociation rate of radical precursors. The experiments at Mace Head have the acronym EASE (Eastern Atlantic Spring/Summer Experiments) and they will take place at two well-defined parts of the ozone seasonal cycle, spring and summer. Subsidiary experiments will be carried out at Aberystwyth with the ozone profiling LIDAR (OZPROF). Additionally there will be longer-term studies at Mace Head and Weybourne called LTERM (Long-Term Studies of Chemical Climatology).

Ice Core Studies will extend these investigations into the composition of the atmosphere in the northern hemisphere back into the last century.

These ACSOE-funded activities will be extended and complemented by close collaboration with external research programmes such as TACIA (EU), HALOTROP (EU), NARE (US/International) and FREETEX (Swiss DoE). TACIA is a C-130 based experiment with broadly similar aims to the LAGPRO experiments (described later), focusing specifically on chemical processing in continental plumes, advected over the Atlantic under anticyclonic conditions. HALOTROP aims to study reactive halogen chemistry at coastal sites (Mace Head or Weybourne). NARE is a study of gas-phase chemical processing during long-range transport across the Atlantic. A major deployment of large US research aircraft (NASA DC-8 and NOAA WP-3) alongside the MRF C-130 is at an early planning stage for a joint ACSOE-NARE-TACIA experiment in late summer 1997. FREETEX, based primarily at the Jungfraujoch (Switzerland), will allow high altitude measurements of radical species, and comparisons with C-130 instruments.

Objectives of EASE

- Investigate the chemical production and loss mechanisms of atmospheric oxidants in the marine boundary layer.
- Determine the role of photochemically produced radical species in the ozone cycle in the marine boundary layer.
- Investigate the speciation of oxidised nitrogen and its consequences for long range transport and photochemical processing.
- Characterise the air masses arriving off the West coast of Ireland and determine whether trace gas composition is indicative of the source of the air mass.
- Quantify the extent of NO_y chemistry in the marine atmosphere over the Atlantic Ocean.
- Investigate the extent of halogenation chemistry occurring over the Atlantic Ocean.
- Study the extent of NO_3 chemistry, particularly its impact on DMS and hydrocarbons

2.2.1 EASE: Eastern Atlantic Spring/Summer Experiment

The ozone record at Mace Head on the west coast of Ireland shows episodes of ozone production and loss superimposed on a seasonal cycle characterised by a spring maximum and a summer minimum. Two comprehensive experimental campaigns will be conducted to study tropospheric photochemistry of ozone and HO_x/RO_x free radicals at this field site: EASE 96 will take place during the summer (July-August 1996) when background ozone is normally at a minimum. EASE 97 will be carried out when ozone levels should be at a maximum (March-June 1997) due to wide-scale ozone production in the background atmosphere from precursors emitted on the continents. Studies of the extent of NO_3 chemistry, particularly its impact on DMS concentrations, will be undertaken in 1996 and 1997, as well as studies of halogen chemistry. During the EASE 97 campaign there will be the opportunity for combined ground, ship and air-borne measurements during a joint OXICOA/MAGE campaign which will mirror some of the activities planned for ACE later that year. In EASE 96 the Cranfield Jetstream aircraft will be deployed in experiments to characterise the vertical and horizontal homogeneity of the air mass.

The dominance of the ozone production or loss processes is dependent on the composition of the air mass advected to the site. Ozone loss occurs in clean polar or sub-tropical air due to deposition and chemical sinks. In polluted air high NO_x concentrations and photochemical processing result in ozone production. This is typical of air advected from Europe or of long range transport of well aged polluted air from North America especially in springtime. We will take advantage of the meteorology at Mace Head to study oxidant production and loss processes at a single well equipped experimental site in a variety of air mass types. Trajectory analysis will allow us to characterise the air masses reaching the site by source region.

The complex atmospheric chemistry which determines OH concentrations will also be studied. We will use the chemical schemes developed in TIGER and LOIS which involve the observation of the physical and chemical parameters affecting OH radical concentration and the inclusion of these in detailed chemical modelling. A central part of the EASE 96 experiment is the first experimental deployment of the University of Leeds FAGE system for measurement of the OH and HO_2 radicals. The direct

measurement of these species will provide an excellent opportunity for testing the chemical models used to determine OH concentrations.

Of great importance for both ozone and OH are the oxidised nitrogen species which play a pivotal role in oxidant chemistry: NO_x can lead to either production or loss of ozone, is important in the cycling of HO_2 to OH and acts as a sink for OH. In polluted air NO_x produces ozone, but at the very low concentrations typical of the remote marine environment, ozone is destroyed. The transport of oxidised nitrogen species to the remote marine environment is often via stable, photochemically produced organic reservoir species. These are less reactive than NO_x and can be transported over long distances in the free troposphere but will thermally decompose to yield NO_2. During EASE 96 we will study the production of these species from photochemical air pollution and their transport in the marine atmosphere. By conducting the EASE 96 experiments in spring and summer seasons we will experience different levels of photochemical activity, during spring the predominant species will be PAN while in summer a wider range of organic nitrates will be present. Chemical modelling of polluted air masses will be an essential feature of the balancing of the NO_y budget as it will identify those species which can not be observed experimentally.

Nitrate radicals may be an important reactant for removing various gases particularly DMS and olefins from the atmosphere in addition to OH. Measurements of NO_3 will be made at Mace Head both before and during the expected maximum which occurs in DMS concentration in June. Measurements of halogen oxide radicals will also be attempted at Mace Head in conjunction with a survey of potential organic halogen source gases.

2.2.2 AMCHEX: Air Mass Characterisation Experiments

Various air masses will be characterised by systematically collecting a database using the comprehensive instrumentation which will be fitted to the C-130 (Appendices A.1.1 and A.3). Depending on flying time availability flights will be made at different times of the year in air masses of various origin (primarily tropical maritime and polar maritime). Where flight plans permit, these may include studies of the impact of the polar front and sub-tropical jet as barriers to north/south transport, and their effect on containing trace gases within the polar and mid-latitude regions, respectively.

In other experiments, the degree to which polluted boundary layer air is transported to the free troposphere by frontal 'conveyor belts' will be investigated by flights across frontal systems. Furthermore, the vertical structure of the troposphere across the boundary layer and through the free troposphere will be investigated by making profile measurements. In the latter case, measurements made in the vicinity of ground stations will enable links to be made between the aircraft and ground data, and to assess the degree to which ground stations are connected to the free troposphere (cf. Section 2.2.6). The Jetstream aircraft will also play an important part in these latter studies during EASE 96.

The photochemical histories of the various air masses will be examined via measurements of many gases, and also aerosols, in vertical profiles from the sea surface to ceiling. The database will be used to determine the oxidising capacity and the budget of tropospheric marine air in the northern hemisphere. Interpretation of the data from the various experiments will be carried out using simple chemical algorithms both in near real time on board the C-130 and post event. The large database collected will be highly valuable in the validation of 3-dimensional models.

2.2.3 LAGPRO: Lagrangian and Chemical Processing Studies

Experiments will be carried out using the comprehensive instrumentation which will be fitted to the C-130 (Appendices A.1 and A.3) to examine the photochemical processing within defined air masses. These could include the detection of long-range transport events crossing the Atlantic from North America and from Europe in summer and winter; from polar outflow down the North Sea in spring, and outflow of continental

air from Europe over the ocean (Atlantic or North Sea) in summer anticyclonic conditions. The latter process with be studied in conjunction with the EU project TACIA (Testing Atmospheric Chemistry In Anticyclones).

The approach will be to make quasi-Lagrangian measurements, attempting to intercept plumes predicted by trajectories. The observed evolution of the air parcel composition will be compared to that predicted by atmospheric chemistry trajectory models. Specifically, the loss of source gases (hydrocarbons, NOx) and production of oxidants (ozone, peroxides, PAN) will be studied. In some circumstances it may be possible to select conditions with trajectories passing over (or close to) Mace Head and Weybourne, which will allow the ground based measurements to be verified and to be incorporated into the analysis, looking specifically at loss of NO_x and NO_y and conversion between nitrogen species during transport. A further variation on this theme would be an inverse Lagrangian study linking aircraft measurements of the chemical 'history' of air masses in the Atlantic with measurements made at Mace Head of the same air mass. Trajectory models will be used in the planning and interpretation of the LAGPRO experiments.

2.2.4 NITELIFE: Vertical Profiles of NO_3 Lifetime

Vertical profiles of the tropospheric lifetime of NO_3 will be determined using aircraft measurements of NO_2 and O_3 together with a ground-based (Weybourne) zenith-pointing absorption spectrometer (DOAS) at sunrise. These can then be compared with simultaneous aircraft measurements of the known radical sinks. This will require night-time/dawn flights of the C-130.

2.2.5 OZPROF: Ozone Lidar Profiles

Considerable variation in ozone concentrations are seen in the free troposphere, both vertically and horizontally. Continuous measurements with an ozone LIDAR at Aberystwyth will enable the dimensions of these variations and structures to be ascertained, as they are advected over the study site. The occurrence of these structures, from about 3 km to the tropopause, can then be related to meteorological features and source regions. From summer 1996 it is hoped that both day-time and night-time measurements will be possible.

2.2.6 LTERM: Long Term Measurements of Chemical Climatology

In addition to the campaign-type activities which will constitute the major part of the experimental work in ACSOE, several longer-term measurement programmes will be undertaken at the two principal ground-based sites, Mace Head and Weybourne, which will also involve the C-130. Further information will become available from Cape Grim in the southern hemisphere, from the free tropospheric site on the Jungfraujoch, and possibly other remote sites. These other measurements will form a useful additional perspective in the interpretation of the major OXICOA experiments.

The ground-based measurements will focus on the various measurements of ozone and its precursors, CO, hydrocarbons and NO_x, and on correlations between ozone and NO_y throughout the annual ozone cycle. These will be complemented by the C-130 experiments described in the preceding sections; particularly the vertical profiling experiments of AMCHEX and NITELIFE. Comparisons with aircraft measurements will allow the representativeness of ground station observations to be assessed, and allow temporal extrapolation of 'snap-shot' aircraft experiments into an impression of average seasonal variations.

2.2.7 FIRE-TRAC: Firn and Ice Record of Trace Atmospheric Chemistry

Ice formed on high glaciers and ice sheets contains air, trapped in bubbles, that can be of considerable antiquity. Deep snow (firn) overlying this ice also holds a record of air dating back several decades. This air can be examined for indications of past atmospheric chemistry and composition using high resolution, high sensitivity organic mass spectrometry (GC-MS). Advantage will be taken of UEA's

links with glaciology groups in the UK (British Antarctic Survey), France and Australia to obtain air from firn and ice cores. These will be examined for man-made halocarbons as a means of dating the air; for natural reactive halocarbons capable of affecting radical halogen chemistry; for organosulphur gases; for hydrocarbons; and for alkyl nitrates as indicators of nitrate chemistry. These observations can then be compared with contemporary measurements in the marine atmosphere made by the main ACSOE programme.

2.3 OXICOA Activities in 1998

The plans for experiments in 1998 have yet to be finalised. It is not likely that an extensive ground-based campaign will be carried out because of financial limitations and also to allow full work-up of data and the essential phase of report writing and preparation of papers for publication in the peer-reviewed literature.

The C-130 aircraft will be available, however, and it can be used for a variety of possible purposes including:

(a) Experiments co-ordinated with the 1998 North Atlantic Experiment of MAGE (June 1998, 60°N, 20°W). The MAGE requirements would be met by chemistry measurements in the marine boundary layer to characterise the evolution of particles formed over the ocean. In addition, OXICOA objectives related to interception of long-range transported plumes of pollution from North America and Europe (LAGPRO: cf. Section 2.2.3) could be met.

(b) Extensive involvement in the INDOEX experiment (January, February, March). The INDOEX experiment has numerous objectives associated with studies of atmospheric chemistry and its relationship to climate in the Indian Ocean. It is hoped to plan a major UK effort involving the NERC ACSOE community and the UK Met Office Research Flight. This experiment would form a component of ITOY (International Tropospheric Ozone Year).

(c) In both the above cases, these experiments might be expanded into co-operative studies with North American Scientists in ITOY involving several aircraft: discussions are currently proceeding with US scientists from the NOAA Aeronomy Laboratory on joint deployments.

3. MAGE: MARINE AEROSOL AND GAS EXCHANGE

Exchange of chemicals across the air-sea interface has important implications for both atmospheric and oceanic chemistry. Trace gases produced in seawater on release to the air can affect the acid/base balance of rain and aerosols, the oxidising capacity of the atmosphere (through breakdown of non-methane hydrocarbons and natural halocarbons), as well as the atmospheric radiation balance (by uptake/release of CO_2, N_2O, CH_4 and the formation of cloud condensation nuclei from the oxidation of DMS). The pH of aerosols and precipitation is largely controlled by the balance between acids coming from fossil fuel burning and oxidation of DMS (to methane sulphonic acid (MSA), SO_2 and SO_4), and bases provided by natural and man made sources of NH_3 and methylamines. On the other hand, deposition of particles and precipitation provide a source of trace substances (e.g. iron and fixed nitrogen) to the euphotic zone of the oceans and its biota. Since many of the above mentioned gases emitted to the atmosphere are biologically formed in the oceans, the up and down fluxes are, in reality, closely coupled and so logically studied together.

A schematic of the main scientific issues to be addressed during MAGE is shown in Figure 3.1. The following is a description of the three experiments to be carried out in the MAGE part of ACSOE:

3.1 Eastern Atlantic Experiment - EAE

The aims of the Eastern Atlantic Experiment:

- to quantify input of DMS into a parcel of air,
- to examine the oxidation of DMS and its reaction with nitrogen species with time,
- to investigate the formation of new particles as a results of these transformations,
- to discriminate between natural and anthropogenic fractions of sulphur and nitrogen using isotopic measurements.

This experiment is an extensive study of the speciation of sulphur and nitrogen in both clean and moderately polluted atmospheres. It will involve the measurement of DMS in the ocean and calculation of fluxes into the atmosphere, combined with the measurement of the speciation of sulphur and nitrogen in both gas and size-fractionated aerosol phases. Isotopic measurements will be used to assess the relative importance of the natural and anthropogenic sources of sulphur and nitrogen, as well as the branching ratio of MSA to SO_2 in the atmospheric oxidation of DMS. The gas-to-particle conversion process and a detailed study of physical and chemical composition of fine particles in North Atlantic air will provide information leading to a better understanding of "bursts" of new particle formation observed previously at Atlantic coastal sites.

The experiment will be carried out in the spring seasons of 1996 and 1997 during the period of maximum DMS production in this ocean area, thus providing a strong natural signal to the atmosphere. Measurements will be made at both a land-based site, Mace Head, and a ship positioned off Western Ireland. The use of the Jetstream and C-130 aircraft will enable linkage of measurements on the ship

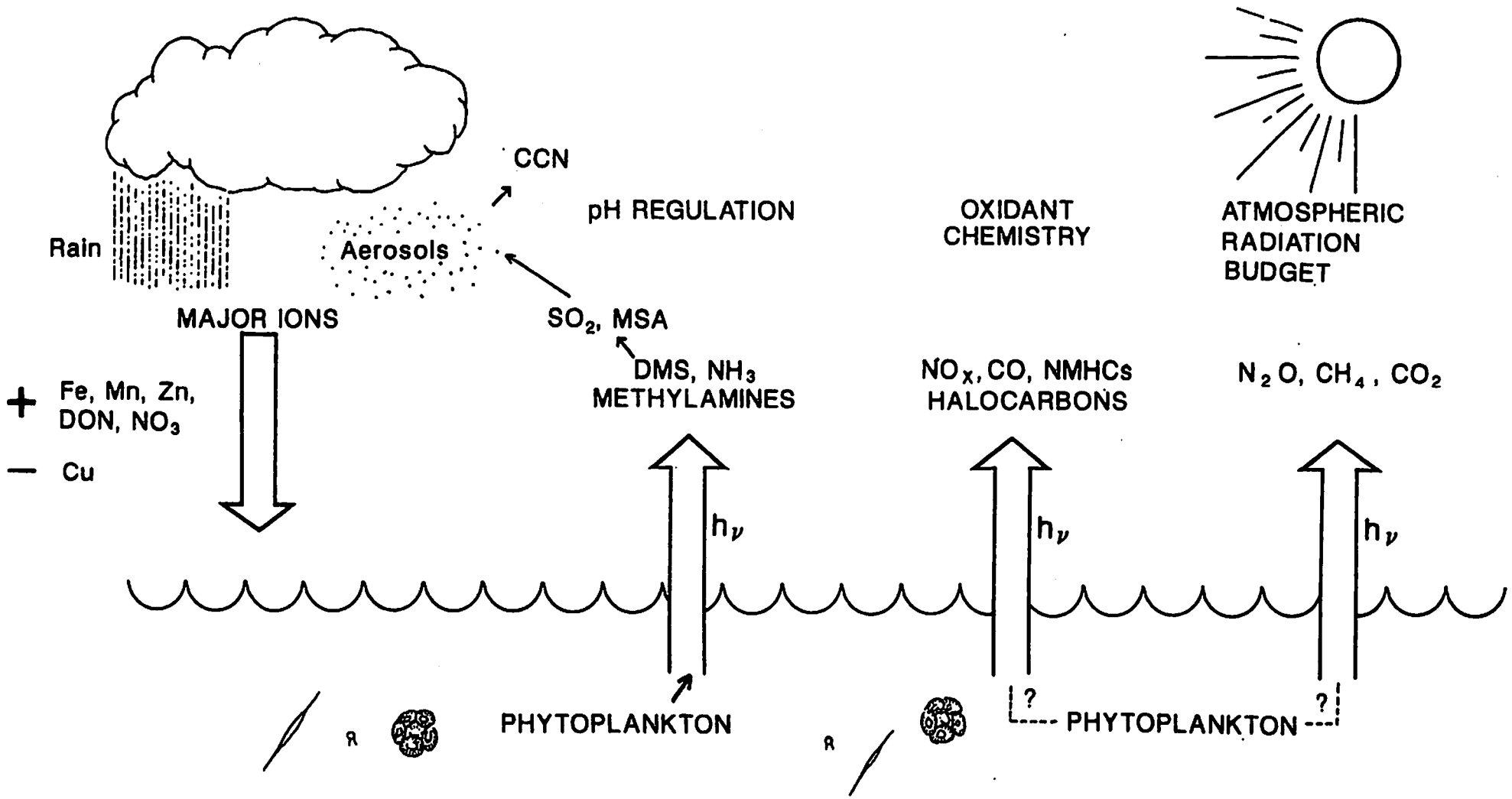


Figure 3.1 Schematic of the scientific issues to be addressed during the MAGE part of ACSOE. Upward arrows indicate an evasion of gases from the ocean into the atmosphere. The gases have been listed in groups with a title indicating their major effect on the atmosphere. The downward arrow indicates wet and dry deposition. + indicates species which, when deposited on to the ocean surface, are believed to have a positive effect on phytoplankton growth, - indicates species which are believed to inhibit phytoplankton growth.

and at Mace Head and, in addition, profiles of aerosol size and distribution throughout the marineboundary layer. An integral part of this experiment is modelling via a zero-dimensional time-dependent photochemical box model of an air mass in the marine boundary layer.

3.2 North Atlantic Experiment - NAE

Questions to be addressed in the North Atlantic Experiment:

- What are the mechanisms producing climatically important gases in seawater?
- How do the rates of production vary with important biological and physicochemical parameters?
- Can the measured gaseous emissions be used in models to identify the major atmospheric transformation processes?
- How does the plankton community respond to atmospheric deposition of nutrients in terms of growth rates and production of climatically important trace gases and their precursors?

The focus of the North Atlantic Experiment will be a study of the linkages between the surface water phytoplankton community, air-sea exchange and related atmospheric chemistry. In order to conduct a truly Lagrangian experiment to follow the development of a bloom, a patch of water will be marked with SF_6 and the evolution of the phytoplankton, and consequent trace gas production/destruction, will be mapped over a period of up to 10 days.

The variations in the scale and relative importance of the emission of various trace gas species, including DMS, natural halocarbons, CH_4, N_2O, methylamines, NH_3, COS and non-methane hydrocarbons (NMHCs) at various stages of a phytoplankton bloom will be investigated. In particular the experiment will attempt to elucidate the effect of different nutrient regimes and grazing pressures on emission, as well as whether emission occurs via direct biogenic emission (as is likely for methane), by processing of biogenic emissions through surface water microbial communities (as occurs for DMS), or from physico-chemical processing of biogenic precursors (as seems likely for COS).

Atmospheric input, by both dry and wet deposition, is the dominant source of several biogenically important trace elements in the surface ocean (e.g. Fe and Mn) and an important source of others (e.g. nitrate, ammonium, Zn, Cu). The nature and scale of the response of the phytoplankton community to the deposition of trace elements is assumed to be a function of the total atmospheric input, the depth over which this is dispersed (a function of wind-induced vertical mixing), the stage of phytoplankton growth and the absolute biochemical requirement for the input material. In terms of the feedbacks in the air-sea exchange climate system, an important unknown is how these responses are coupled to emissions of the trace gases.

Our aim is to carry out a comprehensive atmosphere/ocean and biogeochemical study in association with the international communities in the IGBP's IGAC and JGOFS core projects. It is anticipated that

this will be a dual ship exercise with one ship operating in survey mode to map the patch of SF_6 and biological, biogeochemical and physical parameters in the water column, with the second ship carrying out continuous atmospheric measurements, both over the mapped patch of water and upwind. The experiment is to be carried out during June 1998 at 60° N, 20° W targeting the large (approx. 0.5 x 10^6 km^2) coccolithophore blooms observed in this area. Aircraft overflights are planned to elucidate the chemical and physical evolution of particles in the marine boundary layer. Modelling of the atmospheric transformations in the marine boundary layer will be carried out during this experiment using a zero-dimensional time-dependent photochemical box model.

3.3 ASGAMAGE

Central to modelling and estimating gas fluxes across the sea surface is the rate at which gases move from sea to air, and vice versa. The kinetics of the process are characterised by a transfer velocity (k), which is often parameterised in terms of wind speed. In ASGAMAGE field measurements using purposefully added tracers will be used to relate k to wind speed and other geophysical parameters.

Transfer velocity measurements will be made during October 1996 in the southern North Sea from the *RRS Challenger* using double (SF_6 /^{3}He) and triple (SF_6/ ^{3}He/ bacterial spores) purposefully added tracers. These results will be compared with estimates of k made using eddy correlation approaches from the adjacent fixed platform Meetpost Noordwijk. Simultaneous measurements of concentrations of trace gases such as DMS, CO_2, CO, CH_4, N_2O, halocarbons and NMHCs will be made so that, by combining them with the k values, air-sea fluxes can be obtained.

ASGAMAGE is part of the larger EC funded project of the same name. However, the *RRS Challenger* will be the platform from which the dual and triple tracers will be deployed and from which the climatically important trace gas concentration fields will be measured.

4. ACE: AEROSOL CHARACTERISATION EXPERIMENT

The goal of ACE is 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 to radiative forcing.

ACE Objectives

- To investigate the dependence of the cloud microphysics, cloud chemistry and the properties of the interstitial aerosol on the characteristics of the aerosol and trace gases entering cloud.
- To study the influence of the physical and chemical processes occurring within the cloud on the aerosol size distribution, the aerosol chemical and hygroscopic properties and on the trace gas concentrations in the airstream leaving the cloud.
- To study the effects of entrainment on the cloud microphysics, on the aerosol chemistry and size distribution and the aerosol hygroscopic properties.

To pursue these general aims five integrated field projects will be performed in the sub-tropical North East Atlantic during June and July of 1997. These will be supported by continuous monitoring of the aerosol properties and trace gas precursors, and by a smaller scale pre-campaign on Tenerife in 1996. The basic framework of this experiment, called ACE-2, will be funded by the European Union. By collaborating with other European groups (EU funded) and US groups a much more comprehensive experiment can be performed which will encompass the objectives of ACSOE ACE. The strategy of ACE-2 will be implemented in a series of complimentary activities (see box).

The major contribution of ACSOE is to two of the experiments (3 and 4) designed to look at the modification of cloud microphysics in relation to the aerosol entering cloud and particularly to the changes in the aerosol properties resulting from the chemical processing of aerosol by and in the vicinity of cloud.

In the first experiment, HILLCLOUD, a hill cap cloud which forms over a ridge on the NE of the island of Tenerife will be used as a natural flow through reactor. An additional objective of this experiment will be to characterise the size distribution, size dependent chemical composition and hygroscopic properties of the marine and modified continental aerosol arriving at the North coast of the island. The trace gas concentrations at the same site will be similarly characterised.

The second experiment, LAGRANGIAN, is a Lagrangian experiment which will look at the modification of aerosol as it is advected away from the Portuguese coast over the Atlantic ocean in the cloudy Marine Boundary Layer (MBL). In this experiment the UK Meteorological Office C-130 will follow and sample the same air parcel in order to investigate the evolution of the aerosol and stratocumulus cloud microphysics, as the aerosol in the parcel is subjected to repeated cloud processing. In doing so, each of the processes studied in detail for a single cloud pass in the HILLCLOUD experiment will be investigated.

These experiments will be conducted in a variety of airmasses including those which have a long trajectory over the North Atlantic and which contain background levels of pollution (e.g. from North America), in airmasses which have crossed anthropogenic sources over Europe, and finally, in airmasses which have

ACE-2 (EU/International) Activities

1. CLEARCOLUMN: A study of the radiative effect of aerosols, integrated over a vertical column in the cloud free atmosphere.

2. CLOUDYCOLUMN: A study of the effect of aerosols on the microphysics and radiative properties of MBL clouds.

3. LAGRANGIAN: A study of the aerosol and cloud evolution in an air parcel advecting from the European continent into the MBL (ACSOE contribution).

4. HILLCLOUD: A study of the processing of an aerosol by passing through a single MBL cloud (ACSOE contribution).

5. FREETROPE: A study of the free tropospheric aerosol and its effect on the MBL aerosol and cloud properties.

6. LONGTERM: Long term observations in the ACE-2 area and the larger North Atlantic, from ground based stations and satellites, to provide spatial and temporal context and representativeness of the ACE-2 intensive campaign.

7. ITEGMODEL: Improvement and application of 3-D regional and global models for assessing aerosol radiative forcing over the North Atlantic.

crossed the Sahara desert and which are transporting large amounts of desert dust into the north Atlantic region. More than one of these airmasses may be found at the same time at different levels in the atmosphere, and hence a detailed treatment of the entrainment process will be essential. Modelling of the boundary layer structure, the dynamics, the cloud formation processes, and the homogeneous and heterogeneous chemical processes will be used to interpret the data in both experiments.

Complementary to these studies will be a series of C-130 flights through hill cap clouds on Great Dun Fell, UK and during 'round-Britain' flights to examine the effect on aerosols, CCN, and cloud particles during passage of air masses across the UK (MODCLOD).

4.1 The HILLCLOUD Experiment.

In June and July of 1997, the cap cloud which forms over a ridge in the north-east of the island of Tenerife will be used as a natural flow through reactor to study the evolution of the aerosol properties resulting from a single passage through the cloud. These modifications will be examined as a function of the pre-existing aerosol properties, trace gas precursors and entrainment from the free troposphere. The formation of the cloud on the pre-existing aerosol will be investigated together with the growth of the aerosol particles which act as cloud condensation nuclei (CCN). This modification will result from the scavenging of gas phase species into cloud drops and the aqueous phase production of sulphur and nitrogen compounds. Possible mechanisms for the growth of the Aitken mode aerosol particles which remain interstitial to the cloud droplets will also be investigated. Modelling studies suggest that these particles act as sinks for NO_3 in the atmosphere, enabling them to grow towards sizes at which they will be able to act as CCN in subsequent cloud formation (and hence follow the aqueous phase modification pathways described above).

It is probable that new aerosol particles will be observed in the processed air downwind of the cloud. This may be the result of new nucleation possibly involving sulphuric acid, ammonia and hydrochloric acid or

ammonia and nitric acid. These gas phase species will be emitted from cloud droplets during the evaporation phase. Alternatively, entrainment may introduce gases and newly formed particles from the free troposphere above. There is evidence to suggest that new particle formation may occur in the free troposphere from gas phase precursors transported up from the boundary layer by clouds. Hence, an experiment to investigate the interaction of DMS and its oxidation products with cloud will be performed. Further, isotope studies will be performed on sulphur compounds contained in aerosol and cloud water samples to obtain the proportion of non-anthropogenic sulphur.

These experiments will make use of 5 ground based sites on the island of Tenerife (see section 7.3). Sites 0 and 1 will be used for measuring aerosol properties and trace gas concentrations upwind of the cloud, site 2 for cloud microphysics and cloud chemistry measurements, site 3 for trace gases and aerosol after passage through cloud, and site 4 for trace gases and aerosol within the free troposphere. Appendix 1.3 gives a complete list of ground based measurements for HILLCLOUD. In addition, the MRF C-130 aircraft will perform vertical profiles up to 3000m in the free troposphere above Tenerife, and will make profiles through the boundary layer (BL) and into the free troposphere upwind to the north of the HILLCLOUD sites. It will also conduct horizontal transects above the cap cloud. A portable radiosonde system will be used to make additional profiles through the boundary layer at sites on the North coast of the island. Detailed process modelling will be used to link the data between the sites and to interpret the results.

In order to determine the prevailing concentrations of trace gases and aerosol properties in the range of airmasses that will be experienced in 1997, and to characterise the measurement sites, a pre-campaign will be conducted at each of the ground based sites during June and July of 1996 (see Appendix 1.3).

Other pre-ACE activities designed to aid interpretation of the results from ACE HILLCLOUD and to improve our understanding of the role played by aerosol within clouds, and of the clouds in modifying the properties of the aerosol, have already been undertaken or are planned. In February-March 1995 a large collaborative ground based multi-site experiment (jointly funded by NERC and the EU) was carried out at Great Dun Fell in Cumbria, England. As in ACE HILLCLOUD, the properties of the aerosol and trace gas concentrations were measured upwind, downwind and interstitial to the hill cap cloud, along with measurements of the microphysics and chemistry of the cloud which forms in the moist air as it flows over the Pennine ridge. This data set is currently being evaluated, and the UMIST cap cloud chemistry model is being further developed to aid interpretation. In spring 1994, a smaller experiment (funded by NERC) was carried out at GDF, which included the participation of the MRF C-130 aircraft. The plane made microphysical and radiative measurements at multiple levels within and above both the hill cap cloud and the stratocumulus cloud layers forming upwind and downwind of the Pennine ridge. Measurable modification of the Sc cloud properties attributable to aerosol processing within the cap cloud was observed. A more comprehensive experiment involving the C-130 aircraft is planned for the spring of 1996 to further investigate this result.

4.2 The LAGRANGIAN Experiment.

In the marine boundary layer the evolution of the aerosol mass and number balances can be best studied in a Lagrangian framework i.e. from stations along an airmass trajectory or by using instrumented aircraft to follow and sample the same air parcel. In this way the observed changes can be attributed directly to the chemical and physical processes being investigated.

The Lagrangian phase of ACE will study aerosol modification in a cloudy marine boundary layer. The experiment will be mainly based on flights made by the MRF C-130 and supplemented on occasion by flights by the University of Washington C-131. The aim is to follow an airmass over 2-3 days which implies an advected distance in excess of 1000 km.

In order to follow the same parcel of air it will be tagged with several constant density balloons and inert PFC tracers released from a ship pre-positioned at the start of the trajectory. These balloons will be tracked by satellite and their position relayed to the aircraft. It is envisaged that as the air moves off the continent, cloud will form under the subsidence inversion at the top of the BL due to the injection of moisture from the sea

surface. This will provide the opportunity to study the evolution of the continental aerosol as it is modified by cloud processing, as vertical mixing cycles it through the stratocumulus cloud. Entrainment through the top of the BL will also be studied.

In summary, the LAGRANGIAN experiment will focus on the ACE objectives by the measurement and prediction of:

a) Aerosol depletion in the MBL through exchange with the free troposphere, dry deposition and dilution using inert tracer species.

b) Changes in major gaseous aerosol precursors due to production, depletion and homogeneous gas phase chemistry in the developing MBL.

c) Changes due to in-cloud chemistry of major gaseous aerosol precursors resulting from multiple cloud passes.

d) Changes in the aerosol number size distribution by cycling through clouds including the effects of in-cloud chemistry, coalescence, scavenging in clouds and nucleation in the vicinity of clouds.

The relevant aerosol and gas phase measurements will be performed on the aircraft (see Appendix A.3). In addition the ship will estimate surface sources of DMS, ammonia and other species based on air and water measurements.

A model of the stratocumulus capped MBL will be used to link together the gas and aerosol measurements, and to develop parameterisations of the evolution of the aerosol spectrum.

5. MODELLING

Modelling within ACSOE will form a central role in data interpretation, and also as tools for testing photochemical and microphysical theories. Model results will be validated using data collected during ACSOE. The models cover a number of spatial (point, hill top, trajectory, mesoscale, global) and temporal (diurnal, synoptic, seasonal) domains with varying treatments of chemical (gas-phase, aqueous-phase, heterogeneous) and physical (dynamics, cloud / aerosol microphysics) processes. Details of each modelling contribution and the campaigns in which they will be used are given in Appendix A.2.

Models (trajectory and 3-D) will be used in pre-campaign planning to build up a picture of the variability in chemical and/or aerosol composition in different air masses that can be expected at particular sites (e.g. Mace Head during EASE, and Tenerife during ACE). During certain OXICOA campaigns, chemical measurements (e.g. OH, RO_2, H_2O_2) will be compared with simple chemical expressions based on steady-state relationships and also with near real-time box or trajectory model calculations (including a full treatment of tropospheric chemistry). These modelling studies will test photochemical theory in different airmasses and the impact of physical processes (e.g. mixing, deposition, emissions) on the chemical composition of air reaching a particular location (aircraft or ground-based).

Post-campaign modelling will form a central part of ACSOE data interpretation. A combination of trajectory and 3-D modelling will be used to study a variety of the ACSOE scientific objectives. For example, in OXICOA, models will be used to quantify the contribution of continental polluted plumes to O_3 production in the background free troposphere over the North Atlantic. They will also be used to study the NO_y budget and in particular the contribution of organic nitrates. Other models will also be used to study processes related to CCN production such as DMS oxidation in the marine boundary layer by NO_3, halocarbons and marine hydrocarbons (MAGE - EAE and NAE); modification of aerosol / CCN in continental plumes as they move into the marine environment (ACE - LAGRANGIAN) and cloud processing of aerosol in airmasses of different origin over Tenerife (ACE - HILLTOP).

6. DATA MANAGEMENT

6.1 Summary

The primary task of this initiative is to ensure that data collected during the ACSOE campaigns are stored and distributed in a manner that will enable the maximum benefit to be derived from the data. A major challenge is in the diversity of the data, which includes ground-based, ship-based and airborne instrument data and computer model data. Three components will be involved in this initiative. Firstly, a strategy is needed to enable ACSOE data to be stored and easily exchanged during the operation of the project. Secondly, a strategy is needed for the acquisition and distribution of third party data required for the interpretation of ACSOE data e.g. meteorological data. Thirdly, an archiving strategy is needed so that the data can be used by the wider community long after the project has ended. In all of these components, particularly the latter, it is important to recognise that associated information about the data is an essential component e.g. descriptions of how the data has been acquired and processed.

Data Management Objectives

- To provide a data management and distribution capability for the ACSOE community.
- To organise access to third party data required for the interpretation of ACSOE data
- To develop an archive of appropriate ACSOE data for distribution to the wider community
- To develop an archiving strategy that will ensure the long-term integrity of the data

6.2 Implementation

These objectives will be achieved by the development of a central database at the British Atmospheric Data Centre (BADC) for the storage and distribution of data and information for the project. Data will be acquired, processed and validated by the individual experimenter In the case of the ship data, this will include involvement of the British Oceanographic Data Centre (BODC). The appropriate data will then be converted by the experimenter to the NASA-AMES format and submitted to the BADC along with a description of the data and how it has been processed (see Appendix A.9). Information documents on the format and guidelines for submission of data will be issued to experimenters. Deadlines have been set for the submission of data from each campaign (see Appendix A.9).

On arrival at the BADC, the data will be checked to ensure that the data are readable and will be placed on-line so that other groups within ACSOE are able to access the data. A regular e-mail bulletin will be issued by BADC giving details of new data. During the period of data restrictions (see Appendix A.9), data access will require a user account on a BADC computer. Third party data such as meteorological data that are required for campaign planning and data interpretation will be identified and access to them through the BADC will be organised. This will involve, for example, making ECMWF trajectory data available at BADC and the production of trajectory plots. In addition, a series of standard data plots will be identified and produced systematically for each campaign and made available (probably in booklet form). The use of a standard, popular ASCII format (NASA-AMES) for the ACSOE data will enable the data to be made easily available to the wider community once the

period of restricted data has passed. At the end of the project a CD-ROM (or equivalent) will be produced for distribution to the wider community.

Data Management Deliverables

- A data archiving and distribution system for the ACSOE project for the duration of the project.
- CD-ROM of ACSOE data for distribution to the wider community.

6.3 Links

Good communication between the data centres at BADC and BODC and the various measurement and modelling groups will be essential. This will be achieved by the attendance of data centre personnel at regular ACSOE meetings, by periodic meetings of the data representatives, as appropriate, and by informing the whole team of progress through regular information bulletins.

Links to the wider community will be maintained through the provision of general information on the World Wide Web. Links to other sources of useful data and information will be achieved through the BADC, who maintain various information www pages that point, for example, to other useful www pages.

7. RESEARCH PLATFORMS

7.1 Mace Head Atmospheric Research Station

Location: 53°19'34" N; 9°54'14" W, 10 m above sea level.
Operated by University College Galway (UCG).

Located on the west coast of Ireland, the Atmospheric Research Station at Mace Head, County Galway (Figure 7.1) is unique in Europe, offering excellent westerly exposure to the North Atlantic Ocean (clean sector, 180° through west to 300°) and the opportunity to study atmospheric composition under northern hemispheric background conditions as well as European continental emissions during high latitude anticyclonic conditions. The site location is in the path of the mid-latitude cyclones which frequently traverse the North Atlantic, bringing clean maritime and polar air flow. It is 88 km west of Galway city (population approximately 55,000) which is the nearest major conurbation. The main Atlantic shipping routes are over 150 km away, while the transatlantic air corridors are over 80 km away. There are three small islands offshore which are within the clean sector, but these are uninhabited and do not appear to influence any of the measurements made at the site.

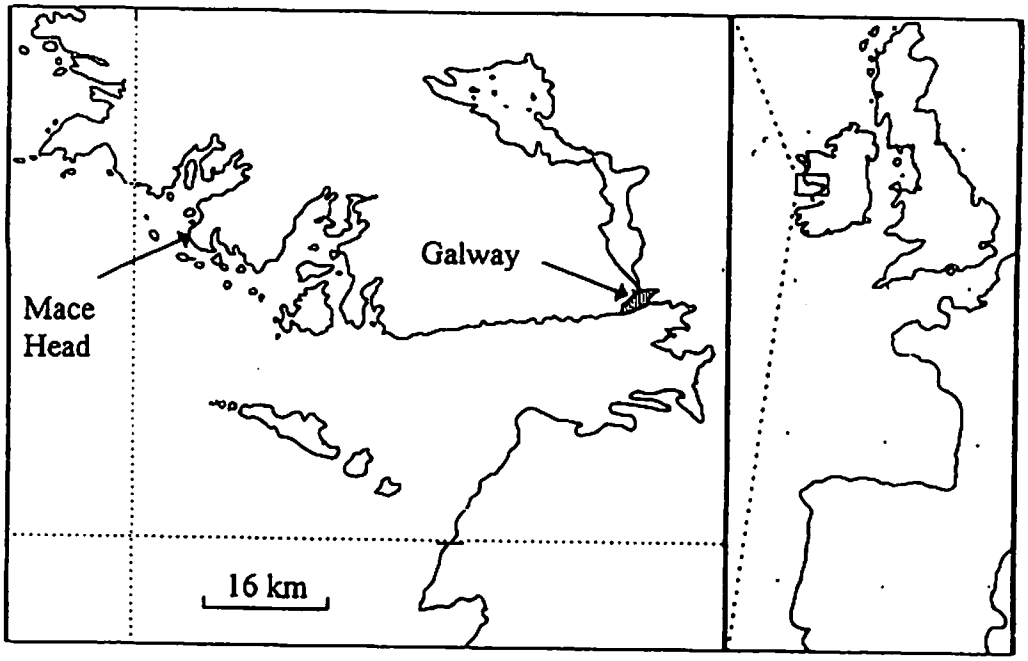
The facilities at the site consist of three laboratory buildings, a converted and extended former cottage at ~300 m from the shore, two purpose-built buildings at ~9 m from the shore (~50 m from high water), a 23 m aluminium walk-up tower at the shore site, a 10 m meteorological tower, and a converted 20 ft cargo container laboratory. ACSOE will add a 10 m walk-up tower at the "cottage". There are also three paved areas outside with electrical power. The site is part of a number of international research networks including AGAGE, AEROCE, WMO/GAW, EUROTRAC (TOR), and the CMDL/NOAA co-operative flask sampling network. Routine measurements at the site include ozone, PAN, CO_2, CH_4, CFCs and other halocarbons, mercury vapour, black carbon, CCN, radon daughters, UV-A, UV-B, and meteorology. Data from many of these instruments will be available to ACSOE investigators. It is very important that ACSOE experiments do not interfere with these established measurement programmes. The Visiting Scientist Guidelines supplied by UCG for visitors to Mace Head is included in Appendix A.11. ACSOE will add an extensive range of analytical instruments, as detailed in Appendix A.1.

7.2 Weybourne Atmospheric Observatory

Location: 52°57'25" N; 1°7'40"E, 15 m above sea level.
Operated by The University of East Anglia

The Weybourne Atmospheric Observatory is a well-equipped atmospheric monitoring station situated at a coastal site near the village of Weybourne in north Norfolk (Figure 7.2). The station building, a converted World War 2 gunnery block house, is situated approximately 75 m from the shore line on a slight rise. The site includes a 10 m instrument tower and glass sampling stack and manifold. The area surrounding the observatory is predominately agricultural but to the west along the coast is an area of salt marshes and mud flats which are internationally renowned for their bird life. This area is often exposed to highly polluted air masses leaving Europe or produced in the UK. Less frequently, Arctic outflow is observed with clean air in summer but polluted Arctic air masses in winter.

The atmospheric mixing ratios of O_3, NO_x and CO and a range of hydrocarbon species, important photolysis rates and standard meteorological parameters are routinely monitored at the observatory which is a recent addition to the TOR and the UK rural ozone networks. A horizontal path DOAS instrument, capable of measuring NO_2, NO_3, HONO, HCHO, O_3 and SO_2, and with a light path over the salt marshes, has also been installed in the observatory. This will soon be joined by a



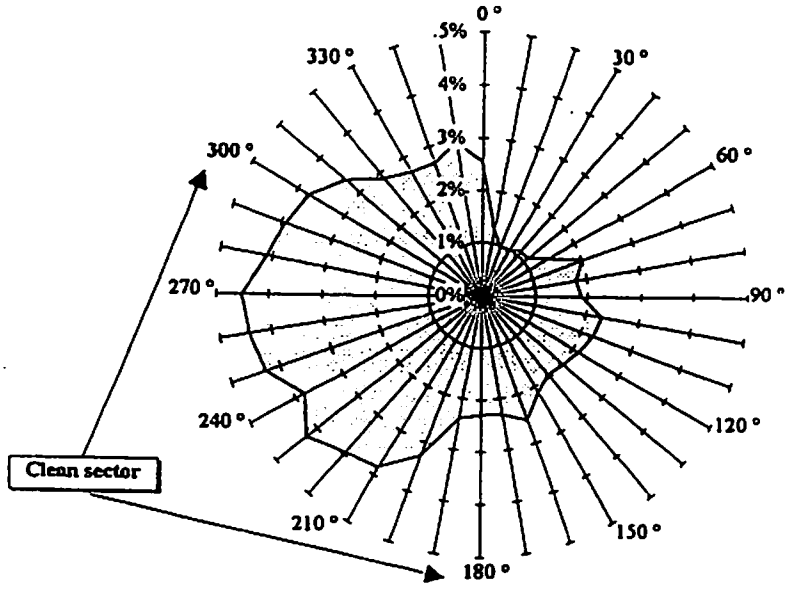


Figure 7.1
Top: Location of Mace Head Atmospheric Research Station, with the clean air sector indicated with dashed lines.
Bottom: Distribution of wind direction at Mace Head, June 1990 to August 1994.

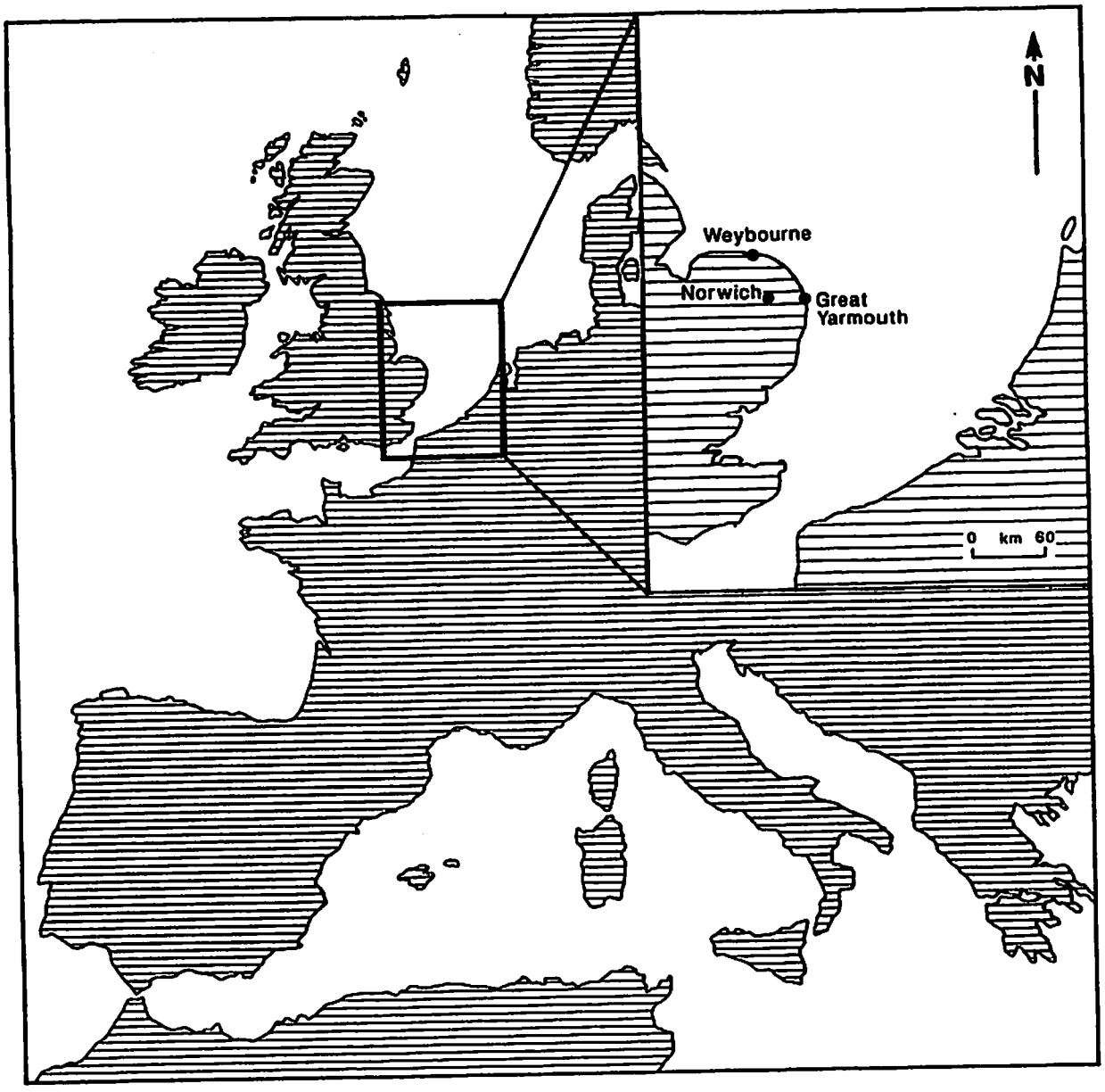


Figure 7.2 Location map of Weybourne Atmospheric Observatory

vertical pointing DOAS for measurement of integrated column depth and vertical profile measurements. During field measurement campaigns the range of instruments deployed at the observatory by UEA will be expanded to include measurement of total NO_y, peroxy radicals, HCHO, inorganic and organic peroxides, PAN and condensation nuclei. The recent addition of an automated, stainless steel sample manifold allows the collection of air samples for later analysis by gas chromatography with flame ionisation detection and mass spectrometry. The observatory has played host to many intensive field measurement exercises including an international DOAS intercomparison exercise and the first UK measurements of atmospheric hydroxyl radical concentrations, as well as TIGER and LOIS campaigns.

7.3 Tenerife

Five ground based measuring platforms will be used during the intensive HILLCLOUD experiments on the island at the sites shown in Figure 7.3. The relative location of sites in the vertical is illustrated in the schematic section through the island.

Site 0 at Punta del Hidalgo on the North coast, is a disused lighthouse on the shoreline. The tower is 55 m high, but space for instrumentation at the top is limited to a footprint area of 5 m^2. A sampling stack will be erected during the campaign in 1997, enabling most instruments to be positioned at the base of the tower where air drawn down the stack from the tower top will be sampled. When measurements cannot be performed in this way (e.g. as for NH_3), instruments will be located at the top of the lighthouse or at Site 1. Site 1 is at Taganana, a village on the North coast of the island to the east of site 0. Site 1 is an empty house situated on the southern edge of the village at an altitude of 220 m It consists of two rooms, a first floor courtyard and a flat roof area. This will serve as a site for upwind gas and aerosol measurements below cloud base but away from the shore line. Site 2 is at the summit of the ridge at an altitude of 660m, and will serve as the main in-cloud site. The large flat roof and upper floor areas of a restaurant at this site are available for use. Site 3 is at an altitude of 500 m on the south side of the ridge. This is a disused shooting lodge and will be used as the downwind post-cloud site. Site 4 is at Izana, at an altitude 2386m. It is a well equipped field site operated by the Spanish Meteorological Service and is part of the TOR network. By night this site will act as a free troposphere site. By day anabatic flow from below will carry local anthropogenic pollution to the site. Sites 0 and 4 are both EU ACE-2 "LONGTERM" and "FREETROPE" measurement sites.

7.4 MRF C-130 Hercules Research Aircraft

The C-130 is large four-engined former transport aircraft operated by the Meteorological Research Flight (MRF), with an RAF crew. It has a maximum range of 5,000 km which, flying from its usual home base at Boscombe Down, Wiltshire, can reach the North Atlantic almost as far as Iceland (Figure 1.3). Its range can be increased by deploying it to other air bases. It will, indeed, be deployed to Tenerife during ACE.

The aircraft can be instrumented in a number of different configurations, which will be customised for the various ACSOE campaigns (Appendix A.9). A large number of continuous instruments can be housed inside the aircraft, taking air from a number of air inlets. High volume pumping systems are fitted to allow aerosol samples to be collected on filter packs, and whole air samples in stainless steel flasks, for later analysis. Radiometers, both upward and downward looking, can be fitted to the exterior of the aircraft. A full suite of aircraft instrument data are also available. Communication with the ground is possible via marine band radio, FAX, and e-mail. A central data acquisition system (DRS) logs data from all instruments. An on board computer (HORACE) enables the data to be viewed in real time, for simple plots to be constructed and even for simple chemical algorithms to be computed for various chemical parameters, thus allowing the flight scientists an instantaneous view of the conditions encountered, and informed decisions on the flight plan to be made. As part of the ACSOE airborne campaigns, detailed meteorological information - including synoptic charts and trajectories (fore-, now- and hind-casting; forward and backward) will be supplied by the MRF for both

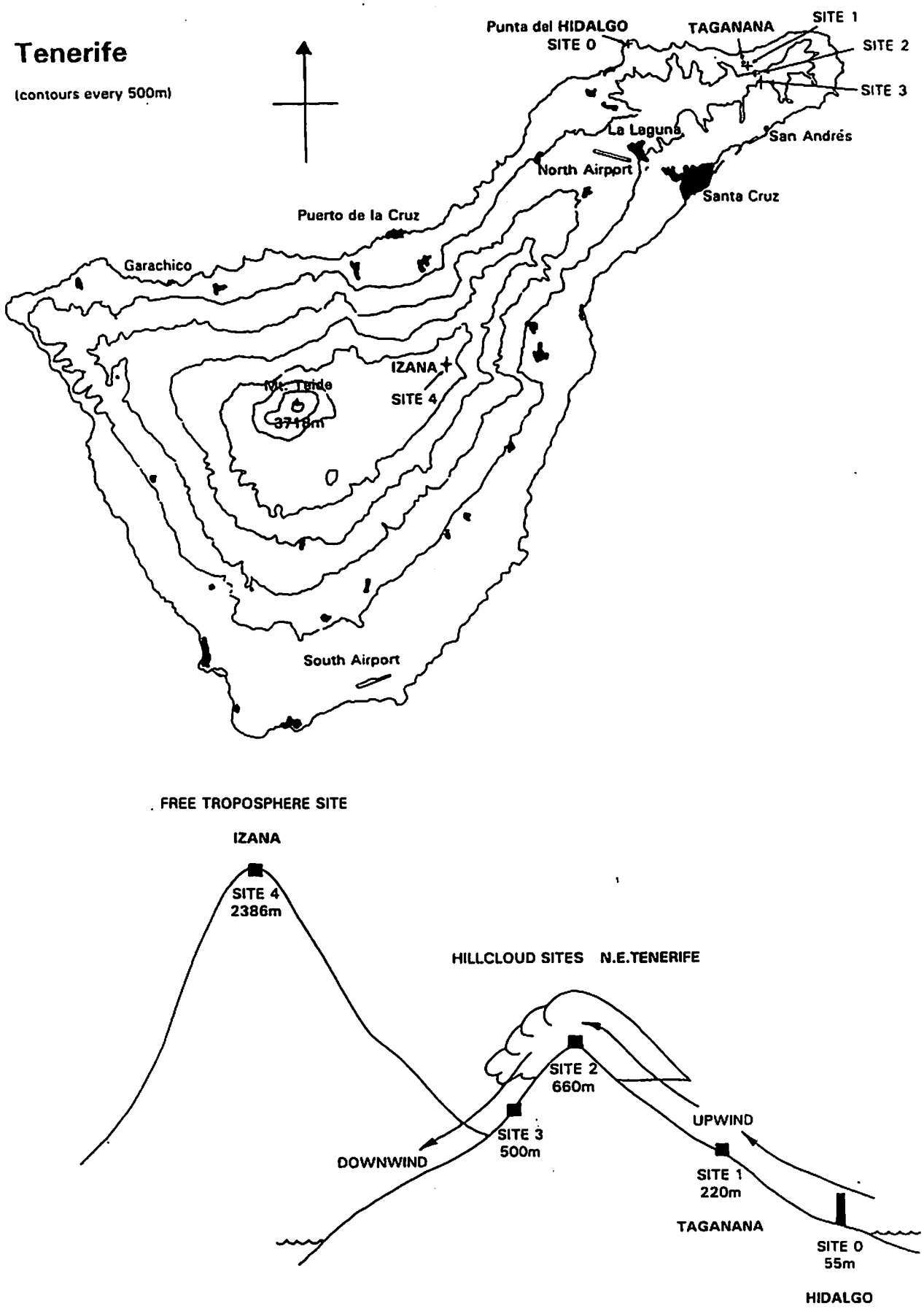


Figure 7.2 Location map of HILLCLOUD ground stations, and cross sectional schematic of this altitudinal relationship

planning and post-experiment interpretative purposes. The MRF will also fully collaborate scientifically, with MRF personnel being involved in making airborne measurements (such as PAN, ozone, aerosols, flask sampling, etc.), and participating in the data reduction and interpretation phases.

C-130 Airborne Laboratory (XV208)

Max. duration:	12 h
Range:	5,000 km
Ceiling:	10,000 m
Minimum operational altitude:	50 m
Operational speed:	270-540 km/h
Aircraft crew:	2 x pilots, navigator, engineer, loadmaster
Scientific crew:	up to 12
Available power for instruments:	21 kW

The C-130 was used very successfully in a CEC-funded forerunner to ACSOE, entitled OCTA (Oxidising Capacity of the Tropospheric Atmosphere). Since taking part in OCTA, several new instruments have been constructed for C-130 use in ACSOE, and several more are proposed. When these installations are complete, the C-130 will become one of the most comprehensively equipped aircraft for studies of tropospheric chemistry in the world.

The new instrumentation includes a 4-channel 'NOxy' system capable of measuring NO, NO_2, NO_y and NO_y-HNO_3 simultaneously with detection limits varying from 1 pptv in 1 sec for NO to 5 pptv in 1 sec for NO_2. A formaldehyde instrument with a detection limit in the range of 50 pptv for continuous operation has been constructed and the peroxide instrument has been modified to measure both H_2O_2 and RO_2H. A TDLAS system has been purchased which will measure NO_2 and formaldehyde with a detection limit of the order of 50 pptv for 1 min integration time. The PAN instrument has been improved such that its sensitivity approaches 10 pptv. Also a new pump has been installed which will enable the collection of filter samples with a higher frequency. Instruments under development include a PERCA to measure peroxy radicals, and a radiometer to measure $J(O^1D)$. All the instruments other than PERCA, TDLAS and $J(O^1D)$ will be fitted by the summer of 1996. The other instruments are scheduled to be fitted by early 1997.

7.5 Cranfield Jetstream Research Aircraft

The Jetstream is a twin turbo-prop aircraft with a more limited range than the C-130. It is owned and operated by the Cranfield Institute for Technology. In ACSOE it would fly with an Imperial College (ACRU) scientific crew and instrument package. The ACRU package (see Appendix A.1) includes a range of continuous chemical analysers for nitrogen species, peroxide, sulphur dioxide, PAN, cloud/rain water major ions, and ozone. A suite of standard physical parameters are also logged, including broad band radiometers. Grab samples of whole air, filter samples, and denuder samples can be collected for post-flight chemical analysis of gases, particles, and adsorbed acidic gases.

Jetstream Research Aircraft

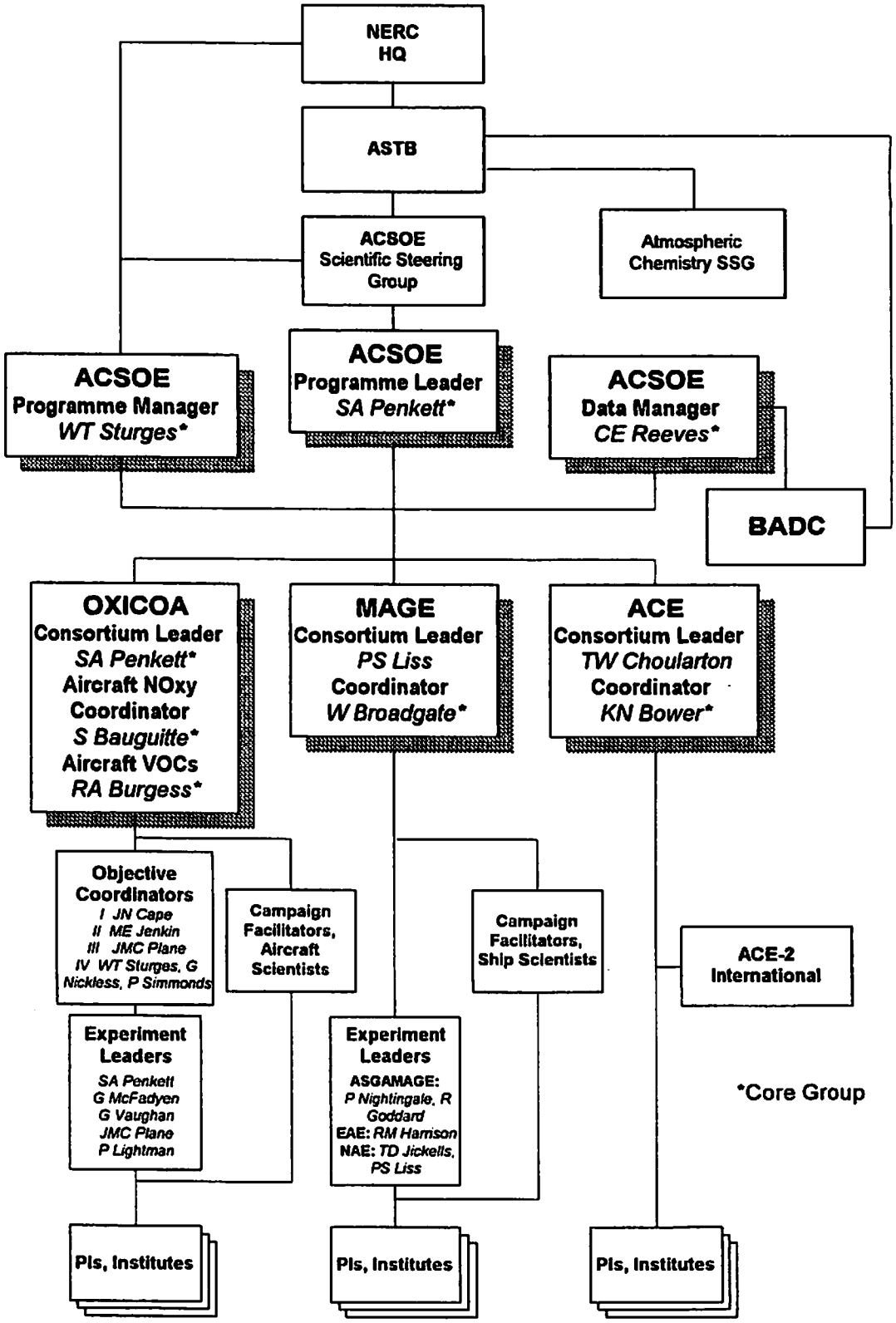
Endurance:	2.5 - 4 h depending on payload
Range:	1100 km
Ceiling:	7600 m (pressurised)
Speed:	200 -330 km/h
Instrument capacity:	480 kg
Aircrew:	2
Observers:	2 - 4 (depending on load)
Power:	2 kVA at 50 Hz (115 or 240 V), 4 kVA at 400 Hz (200 V), 60 A at 28 V DC

7.6 Ships

The majority of the ship time in ACSOE will be on the *RRS Challenger*. This ship is suitable for research in areas close to the continental shelf (ASGAMAGE and Eastern Atlantic Experiments) and has facilities for 14 scientists and technicians. The ship-board computing system will be employed to log continuously measured parameters and data collected on the new meteorological package to be installed before the first ACSOE cruise in June 1996. For the 1998 study, the ACSOE community will be performing a comprehensive coupled atmospheric/biogeochemical study in the open North Atlantic (NAE), requiring the more extensive facilities of *RRS Discovery*. This ship was rebuilt in 1990, can accommodate 28 scientists and has a working meteorological station mounted on a mast at the bow of the ship. In view of the size of the NAE experiment, it is planned to have a second (non-UK) ship working in tandem with *RRS Discovery*.

8. PROGRAMME MANAGEMENT

The ACSOE Management Structure is outlined in Figure A.9.1.



ASCOE Management Structure

9. MEETINGS CALENDAR

Some of the major meetings already held are outlined below, together with tentative dates for some future meetings. It is intended to hold an annual 'All-ACSOE' Science and Planning Seminar, ideally in the first full working week following New Year. This may be combined with individual Consortium meetings. There will also be a number of campaign planning and science meetings taking place throughout the experimental period either as stand-alone meetings or linked to other meetings and science activities.

1995	
Jan 11	MRF/Core Group meeting, RAF Boscombe Down
Feb 27	EAE '96 Pre-Cruise Meeting, RVS, Southampton
Mar 29	ACSOE Review Group sift meeting, London
May 5	ACSSG - ACSOE discussion meeting, London
Jun 26	ACSOE Review Group, Special Topic review, London
Oct 2-4	MRF/ARASF/Core Group meeting, UEA
Oct 12	ACSOE Data Meeting, London
Oct 26-27	Orientation Flight/Briefing, RAF Boscombe Down
Oct 30-31	MAGE Consortium Planning Meeting, UEA
Oct 31- Nov 1	OXICOA Consortium Planning Meeting, UEA
Nov 21	ACE Consortium Planning Meeting, UMIST
Nov 22-25	Core Group Meetings at University College Galway, Valentia Station, and Mace Head site visit
Dec 1	MRF/Core Group instrument meeting, Farnborough
Dec 11-12	'All-ACSOE' Planning Meeting, UEA
Dec 12	ACSOE SSG Meeting, UEA
Dec 13	OXICOA Logistics Meeting, UEA
1996	
Feb 5-7	Implementation Plan writing meeting, Blakeney
Feb 12	N. Atlantic Experiment international linkage, San Diego
Feb 23	ARASF Flight Applications Review Meeting, London
Mar 1	ACSOE SSG meeting, London (including Modelling, Special Topic Review)
Mar 19	ACSOE Data and Trajectory Meeting, BADC
Apr 3	EAE Mace Head Planning Meeting, UEA
Jun 30 - Jul 2	ACE site planning meeting, Tenerife
Oct 28-30	ACE campaign planning meeting, TBA
1997	
Jan	'All-ACSOE' Symposium, UEA
May	OXICOA Seminar, University College Galway
1998	
Jan	'All-ACSOE' Seminar, UEA
1999	
Jan	'All-ACSOE' Seminar, UEA
Jul.	ACSOE International Science Symposium

10. LINKAGES

As well as internal linkages between the three ACSOE Consortia, the Core Group and the Participating Institutes, there exist numerous linkages beyond the programme - nationally and internationally - on various levels from fully-fledged joint experiments (such as ACE-2, ASGAMAGE and TACIA), to bodies with shared interests and reciprocal data arrangements. The result for the ACSOE Programme is an extension of its scope and capabilities beyond that which would have been possible in isolation, and its elevation into an international community activity.

ACSOE Links

NERC - funded:	BADC	BODC	PML
	ITE	UGAMP	IFMA
	BAS		
UK (non-NERC):	DoE - Hadley Centre, NETCEN		
	UK Meteorological Office		
European:	ACE-2	ASGAMAGE	
	TACIA	HALOTROP	
	PRICE-II	TOASTE	
	EUROTRAC 2	EPICA	
	MOZAIC		
	University College Galway		
	Irish Meteorological Office		
	University of Bern/DoE (Swiss)		
International	IGBP -	IGAC	JGOFS, PAGES
	MAGE	NARE	ACE-2
	ITOY - INDOEX		IPCC
	UNEP	NOAA	CSIRO

APPENDICES

A.1 EXPERIMENT DESCRIPTIONS

The following tables summarise the main components and instrumental deployments of the three ACSOE Consortia. For each Consortium the first table lists the main experiments, dates, and locations. The second tables gives the instruments to be fielded in each experiment, subdivided by platform. The numbers in the grid cross-reference to the Special Topic Awards listed in Appendix A.4. The letter 'C' refers to UEA Core activities.

A.1.1 OXICOA

Table A.1.1.1 Principal OXICOA Activities

EXPERIMENT	DATES	PLATFORM LOCATION	CO-ORDINATOR
EASE 96	8 Jul - 9 Aug 1996	MH, Jetstream Eastern Atlantic	G. McFadyen
EASE 97	Mar - June 1997	MH, C-130 Eastern Atlantic	G. McFadyen
INITEST	Spring 1996 and 97	C-130 North Sea, Jungfraujoch	S. Bauguitte, B. Bandy
AMCHEX LAGPRO	Throughout 1996 and 97	C-130 Range of C-130	S. Penkett
NITELIFE	March - April (Sep - Oct) 1996 & 97	C-130, WAO, MH South N. Sea, E. Atlantic	J. Plane, H. Coe
OZPROF	Jun-Aug & Winter 1996, & 97	Aberystwyth	G. Vaughan
LTERM	96, 97 and 98	MH, WAO	S. Penkett
FIRETRAC	96, 97, and 98	UEA Firn Air, Ice Cores Antarctic	W. Sturges

Table A.1.1.2 OXICOA Instrumentation

SPECIES	INSTRUMENT / SOURCE	EASE96	EASE96	EASE97	C-130 96	C-130 97	NITELIFE	OZPROF	LTERM	LTERM	FIRETRAC
		MH	JS	MH	C-130	C-130	WAO	Aber	WAO	MH	
OH, HO_2	FAGE	8		8							
RO_2	PERCA	2		2		2					
O_3	CRANOX	C		C			C		C	C	
O_3	UV Monitor	4		4						4	
O_3	Bendix		X								
O_3	Ozone				M	M					
O_3	Lidar							9			
O_3	TECO49						C		C		
NO	CRANOX	C,6		C,6			C		C	C	
NO	Scintrex	5		5							
NO	NOXY	1			1	1					
NO	NCAR NO/NOY		X								
NO	Monitor Labs 8840		X								
NO_2	CRANOX	C,6		C,6			C		C	C	
NO_2	Scintrex	5	X	5							
NO_2	NOXY	1			1	1					
NO_2	DOAS	3		3							
NO_2	TDLAS	7				7					
NO_3	DOAS	3		3			3				
PAN	Packed Column GC-ECD	C,6		C,6	M	M					
PAN	Capillary Column GC-ECD	4		4					4		
PAN	GC-CLD (Scintrex LPA-4)	5		5							
HNO_3	NOXY	1			1	1					
HNO_3	Scintrex	5		5							
HNO_3	Denuder	5		5							
HNO_3	Continuous	5		5							
HNO_3	TDLAS					7					
HONO	Denuder	5		5							
HONO	DOAS	3		3			3				
HONO	Continuous	5		5							
Alkyl nitrates	GCMS										C
Alkyl nitrates	GC-ECD	C		C	C	C					
NO_Y	NOXY	1			1	1					
NO_Y	TECO42	C,6		C,6			C		C	C	
NO_Y	Scintrex	5		5							
NO_Y	NCAR NO/NOY		X								
JNO_2	Radiometer	C,6	X	C,6	M	M	C		C	C	
JO^1D	Radiometer	C		C		C	C		C		
Solar Radiation	Broadband Radiometer	C	X	C	M	M	C		C		
UV/Visible Radiation	NRPB	G		G							

Table A.1.1.2 Continued

SPECIES	INSTRUMENT / SOURCE	EASE96	EASE96	EASE97	C-130 96	C-130 97	NITELIFE	OZPROF	LTERM	LTERM	FIRETRAC
		MH	JS	MH	C-130	C-130	WAO	Aber	WAO	MH	
C_1-C_{12}	Automated Injection GC-FID	8		8							
C_2-C_8	Cryotrap, GC-FID	C	C	C	C	C	C		C	C	C
Peroxides	Peroxide Analyser	C			C	C					
HCHO	Formaldehyde Analyser	C			C	C					
HCHO	DOAS	3		3							
HCHO	TDLAS	7				7					
H_2O	Dew Point	6		6	M	M					
CO_2	NDIR	4		4						4	
CO	GLC/ECD/FID	4		4						4	
CO	RGA3						C		C		
CO	CO Monitor				M	M					
CO_2	Siemens Ultramat SF	G		G							
CH_4	GLC/ECD/FID	4		4						4	
N_2O	GLC/ECD/FID	4		4						4	
Methyl Chloroform	GLC/ECD/FID	4		4						4	
$CHCl_3$	GLC/ECD/FID	4		4						4	
HFCs	ADS/GC/MS	4		4						4	
HFCs	ADS/GLC/ECD	4		4							
CFCs	GLC/ECD/FID	4		4						4	
CFCs	ADS/GC/MS	4		4						4	
Halocarbons	ADS/GLC/ECD	4		4							
Halocarbons	GCMS	C		C						C	C
BrO	DOAS	3		3							
OClO	DOAS	3		3							
Black Carbon	Aethalometer	G		G							
Radon	Radon Instrument	G		G							
CN	CN Counter	G,5		G,5	M	M	C		C		
CCN	CCN Counter	G		G							
Aerosol surface area	Epiphaniometer	5		5							
Aerosol Size Distribution	ASASP-X/LAS-X	G		G							
Aerosol Size Distribution	DMA System	G		G							
Aerosol Volatility	Heater Intake System	G		G							
MSA, Cl^-, NO_3^-, SO_4^{2-}, CH_3COO^-, $HCOO^-$, NH_4^+, Na^+	MOUDI Impactor	5		5							
MSA, Cl^-, NO_3^-, SO_4^{2-}, CH_3COO^-, $HCOO^-$, NH_4^+, Na^+, NH_3, HONO, HNO_3, SO_2, HCOOH, CH_3COOH	Filter pack	5		5	C	C					

Table A.1.1.2 Continued

SPECIES	INSTRUMENT / SOURCE	EASE96	EASE96	EASE97	C-130 96	C-130 97	NITELIFE	OZPROF	LTERM	LTERM	FIRETRAC
		MH	JS	MH	C-130	C-130	WAO	Aber	WAO	MH	
Met Parameters	AWS	C,G		C,G			C		C		
Met Parameters	Met Sensors				M	M					
Temperature	Rosemount		X								
Winds	GPS		X								
Back Trajectories	ECMWF/BADC	C		C			C		C	C	
Back Trajectories	UK Met Off / MRF				M	M	M				
Forecast Trajectories	ECMWF/BADC	C		C							
Forecast Trajectories	UK Met Off / MRF				M	M	M				
Met Forecasts and Analysis	Irish Met Service Fax	C		C							
Met Forecasts and Analysis	UK Met Off Fax						C		C	C	
Met Forecasts	UK Met Off / MRF				M	M	C				
Hemsby Radiosonde	UK Met Off / BADC						C				
Valentia Radiosonde	Irish Met Service / BADC	C		C						C	
IR/Vis Satellite Images	UK Met Off WWW	C		C						C	
M = MRF	= Imperial College Jetstream			G = University College, Galway							

A.1.2 MAGE

Table A.1.2.1 Principal MAGE Activities

Experiment	Acronym	Dates	Location	Co-ordinator
Eastern Atlantic Experiment 96	EAE 96	6 Jun - 5 Jul 1996	MH, ship	R. Harrison
Eastern Atlantic Experiment 97	EAE 97	May 1997	MH, ship	R. Harrison T. Jickells
Air Sea Gas Exchange Experiment	ASGAMAGE	17 Oct - 1 Nov 1996	Southern North Sea	P. Nightingale R. Upstill-Goddard
North Atlantic Experiment	NAE	Jun 1998	North Atlantic 60°N, 20°W	P. Liss T. Jickells

Table A.1.2.2 MAGE Instrumentation

Species	Instrument	ASGAMAGE	EAE 96	EAE 96	EAE 96	EAE 97	EAE 97	NAE 98
		Ship	MH	Ship	C-130	MH	Ship	Ship
Gases								
NO/NO_2	Scintrex LMA-3		12					12
NO_y	Scintrex		12					12
HNO_3, SO_2, NH_3	Impregnated Filters		12	12				12
Aerosols								
CH_3COO^-, $HCOO^-$, CH_3SO^{3-},	Filter collection		12	12				12
Cl^-, NO^{3-}, SO_4^{2-}, NH^{4+}, Na^+	Filter collection		12	12				12
Fuch's surface area	Epiphaniometer		12					12
Size fract. chemical composition	MOUDI impactor		12					12
Size seg. trace metals and major ions	Filter collection		13					13
Size seg. N isotopes	Filter collection		13					13
SO_4^{2-}, MSA, SO_2, S isotopes	Filter collection		14	14				
Metals, major ions, N & S isotopes	Filter collection		13,14	13				13
Aerosol size and volatility	SMPS, ASASP, FSSP,		16		16			
	OAP, volatility							
Aerosol size distribution	ASASP-X, LAS X, DMA		UCG					
Aerosol volatility			UCG					
Condensation nuclei (CN)	TSI 7610/Nolan/Pollak		UCG					
Cloud condensation nuclei (CCN)	DH ass. model M1		UCG					
Radon	Radon instrument		UCG					
UV/Visible Radiation	NRPB		UCG					
Soot carbon	Aethalometer		16, UCG		16			
SO_4^{2-}, MSA and other aerosols	Filter collection		17					
SO_2	Pulsed fluorescence		17					
Rain								
Metals, major ions, N & S isotopes	Rain collection		13,14	13				13
Dissolved gases								
DMS (g)	GC		17					
SF_6 (aq)	GC	14						14
^3He (aq)	MS	14						
NMHCs (aq,g)	GC	14						14
Halocarbons (aq)	GC							14
CH_4	GC	RUG						
N_2O	GC	RUG						
CH_3Br	GC	JB						
CO	GC	CL						
Other measurements - atmosphere								
Met parameters	AWS, ship met station	RVS	C, UCG	RVS			RVS	RVS
Other measurements - ocean								
Bacillus globigii spores	Incubator	14						
Bubbles	Quadropod	DW						
Salinity	Thermosalinograph	RVS	RVS	RVS			RVS	RVS
Temperature	Thermosalinograph	RVS	RVS	RVS			RVS	RVS
Fluorescence	Turner fluorometer	RVS	RVS	RVS			RVS	RVS
Navigation data	Ship instrumentation	RVS	RVS	RVS			RVS	RVS

Key:
Numbers refer to Principal Investigators (Appendix 4)

C - Core
RUG - Rob Upstill-Goddard (UN);
CL - Cliff Law (PML)
UCG - University College, Galway
JB - Jonathan Baker (UEA);
DW - David Woolf (SOC)

For Jetstream instruments in EAE96, see Table in A.1.1 under EASE 96. Meteorological and Trajectory details same as in Table A.1.1.2

A.1.3 ACE

Table A.1.3.1 Principal ACE Activities

Experiment	Start date	End Date	Location	Leadership
ACE-96 HILLCLOUD	23/06/96	14/07/96	Tenerife	Prof. T.W. Choularton/ Dr K.M. Bower
ACE-97 HILLCLOUD	15/06/97	31/07/97	Tenerife	Prof. T.W. Choularton/ Dr K.M. Bower
ACE-97 LAGRANGIAN	15/06/97	31/07/97	Sub-Tropical NE Atlantic: Portugal (Sagres) and Canary Islands (based on Tenerife)	Mr D.W. Johnson
Other Events				
ACE2-97 HILLCLOUD preliminary meeting	30/06/96	02/07/96		
ACE2-97 HILLCLOUD planning meeting	noon 28/10/96	noon 30/10/96		

Table A.1.3.2 ACE Instrumentation

Measurement	Instrument	ACE Experiment									
		HILLCLOUD-96 : Platforms					HILLCLOUD-97 : Platforms (includes C130 part-time)				
		H0	H1	H2	H3	H4	H0	H1	H2	H3	H4
Gas Phase Species											
SO_2	Saltzmann Tech(L) Envirotech (H) Teco 43 (H)	EU				EU	EU	EU EU	 18	EU 19	EU
NO_y	Teco 42							18			
NO, N_{O2}	Tecan Scintrex LMA3 ?	19 (1+ instrument moved between sites)					EU	18	EU	EU	
NO_2	Diffusion Tubes (H)	18 To be deployed at up to 10 sites									
NO_3	DOAS1 DOAS2							21		 21?	
PAN	GC/ECD (H) Scintrex LPA4 (L)							18 EU			
CO	?	EU				EU	EU				
O_3	Teco 49 ML8810 ?	 EU				 EU	 EU	18	19	 EU	 EU
NH_3	AMANDA							18			
NH_3	Diffusion Tubes (H)	18 To be deployed at up to 10 sites									
H_2O_2	in-house ?							19		 EU	 19?
HCHO	?									EU	
NH_3 HONO HCl HNO_3 SO_2 Formic+ Acetic acids	FILTER PACK							EU		EU	
DMS + products	FILTER PACK COFER Anal's GC(FPD/MS) ? Canister Samples	 EU 19	 19	 19	 19	 EU 19	 EU	EU 20 20		EU 20	 EU
BrO OClO IO ClO SO_2 HONO NO_2 HCHO O_3	DOAS1 additional gases (decreasing detection limits)							19			
H_2O (vapour)	Dewpoint hygrometer							18			
N.B. for gases: (L) = low(er) detection limit, (H) = high(er) detection limit instruments											
Aerosol Properties											
Size Distribution	UDMPS DMPS APS OPC(0.3-20mm)	EU EU	 19?<3 m		 19?<3 m	EU US US	EU EU EU	EU 19	EU	EU 19<3 m	EU US US

Table A.1.3.2 Continued

Measurement	Instrument	ACE Experiment									
		HILLCLOUD-96 : Platforms					HILLCLOUD-97 : Platforms (includes C130 part-time)				
		H0	H1	H2	H3	H4	H0	H1	H2	H3	H4
Aerosol Properties (Cont'd)											
Hygroscopicity	HTDMA UFTDMA(chem)						EU			EU EU	EU
Total CN	TSI 3025 TSI 3010 TSI 3760	EU EU	EU	EU	19	US US	EU EU	EU?		19	
CCN		EU					EU			EU	
Chemistry (all major ions)	4-stage IMP (+bulk/filt head) MOUDI IMP HI-VOL (bulk) FILT STACK FILTER PACK	 EU	EU EU EU	 EU	 	 EU	 US* EU EU	EU EU EU*$ EU*# EU*	 20*	EU EU EU*# EU*	 US* EU
		where: * inc MSA, # inc S isotopes+SO_2, $ inc acetic+formic acids									
Total elemental comp, speciation of inorganics, C volatility	Cascade IMP (analysis by ion beam tech, PIXE, PESA, cPESA, pNRA, H-coinc)							EU		EU	EU
Single Particle Analysis							EU	EU		EU	EU
SAM	sub m sampler + PIXE analysis							EU		EU	
Mass	6 stage IMP (+bulk/filter head) 9 stage IMP (+bulk/filter head)						US EU	EU EU EU EU		EU EU	US EU
Black C	size seg filters 11 stage IMP (analysis by ISP)							EU EU			
Light Scattering	NEPHELOMETER	US				US	US				US
Light Absorption	AETHALOMETER	EU				US	EU				US
Surface Area	EPIPHANIOMETER							EU			
Cloud Properties											
Liquid water content	PVM			19					19		
Drop size distiribution	FSSP			19					19/E U		
Drop/aerosol/ Residue size distributions	Droplet Aerosol Analyser								EU		
Raindrop spectra	PMS GBPP100								EU		
Cloud water collectors	PASSIVE (bulk) ACTIVE (2 stage)			19/1 8					19 EU		

Table A.1.3.2 Continued

Measurement	Instrument	ACE Experiment									
		HILLCLOUD-96 : Platforms					HILLCLOUD-97 : Platforms (includes C130 part-time)				
		H0	H1	H2	H3	H4	H0	H1	H2	H3	H4
Cloud Properties (Cont'd)											
Continuous cloud water chemistry	pH fixed ion strength S(IV) sol'n stripping H_2O_2 NH_4^+ gas electrode NO_2^- stop flow FIA								18 18 19 18 18		
Bulk cloud water chemistry	Major ions, pH, elemental C, Fe, Mn, HCHO, aldehydes & organic acids								EU		
	Major ions, S isotopes								EU		
Other Measurements											
Meteorology	AWS', Sonic-anemometer, Radio/tether sondes	EU	19	19 19	19	EU	EU	19 EU	19 EU	19	EU
Radiation	j-NO_2 j-$O(^1D)$							18 18?		EU?	

EU = ACE-2 EU Collaborator; US = US Collaborator
For Lagrangian C-130 instrumentation, refer to Appendix A.3.

A.2 MODEL DESCRIPTIONS

	Type (chemistry, microphysical treatments)	Institute	Aims	Campaigns
1	Box/Trajectory (gas)	UEA (Reeves, Bandy)	Calculation of concentrations using simple chemical algorithms and Lagrangian models and comparison with data (e.g. OH, RO_2, H_2O_2, NO_x, NO_y)	OXICOA (all)
2	Box/Trajectory (gas, aqueous)	UCamb (Pyle)	Explore validity of photochemical steady-state relationships. Generate suite of chemical simulations for airmasses arriving at Mace Head (climatological average). Run model during campaigns using near real-time (or possibly forecast) trajectories. Compare results to measurements and examine sensitivity of O_3 budget to physical processes (mixing, emissions, deposition) occurring along trajectories.	OXICOA (EASE 96/97, TACIA)
3	Box	IC (Toumi)	Relationships between oxidant and aerosol chemistry. Development of radiative transfer code and comparison with observed photolysis of O_3	OXICOA/ACE
4	Box (gas, aerosol, aqueous, heterogeneous)	UEA (Plane)	Oxidation of DMS, organics and halocarbons by NO_3, removal of NO_y from polluted airmasses in the marine environment; production of CCN from DMS oxidation.	MAGE (N/E Atlantic)
5	Box (gas)	ITE (McFadyen)	Prediction of NO_y species including organic nitrates; identification of species which are yet to be measured.	OXICOA (EASE 96/97)
6	Box (gas)	Leeds	Prediction of OH and HO_2 concentrations and comparison with observations	OXICOA (EASE 96/97)
7	Global (gas)	UCamb (Pyle)	Simulation of 3-D chemical fields using model forced by ECMWF meteorological analyses. Evaluate the contribution of O_3 production in continental polluted plumes to background levels over North Atlantic. Validate model calculations using data (e.g. trace gas ratios).	OXICOA (EASE 96/97, TACIA)
8	Global (gas)	UEA/Hadley Centre (Reeves/ Johnson)	Validate chemical climatologies generated using Lagrangian 3-D tropospheric chemistry model. Examine O_3 and free radical budgets and compare with simple chemical algorithms	OXICOA
9	Lagrangian (gas, aqueous, aerosol microphysics)	UMIST (Choularton)	Formation of aerosol particles. Gas phase chemistry including oxidation of DMS. CCN activation and in-cloud modification due to aqueous-phase chemistry and scavenging of gas species. Modification of aerosol direct and indirect radiative properties.	ACE (HILLCLOUD and LAGRANGIAN)
10	Mesoscale (dynamics, cloud microphysics)	UMIST (Choularton)	Airflow modelling over range of resolutions (100 km→100 m). Resolve airflow over Tenerife. Use with Lagrangian chemistry model to interpret data from HILLCLOUD.	ACE (HILLCLOUD)
11	Large Eddy Simulation (gas, microphysics, aerosol dynamics)	UMIST (Choularton)	Compare measurements with predictions. Includes explicit microphysics and chemistry (see Lagrangian model).	ACE (LAGRANGIAN)

A.3 C-130 INSTRUMENT FITS

The table below lists the planned instrument fit for the C-130 during ACSOE campaigns. It will be noted that power requirements exceed that available for OXICOA and ACE campaigns. Power requirements for some instruments are, however, estimates only. A critical evaluation of power requirements will be made prior to aircraft campaigns and, if necessary not all instruments will be flown on all flights.

Instrument	Power (watts)			Comments
	OXICOA	MAGE	ACE	
"Essential" aircraft instruments:				
DRS (Data system)	90	90	90	
HORACE (on-board computer)	689	689	689	
Lights	108	444	444	OXICOA: Ramp lights off
Power (invertors)	2881	2881	2881	
Van (interior lab)	496	496	496	
Video screens	841	841	841	
General Eastern H2O	115	115	115	
Navigation	608	608	608	
Pressure	7	7	7	
Rosemount heaters	249	249	249	Turn off if not icing
Satellite comms (e-mail/FAX etc)	56	56	56	
Vanes	0	0	0	
Total Essential	6140	6476	6476	
ACSOE Instruments:				
Johnson Williams liquid H2O		99	99	
PCASP/SEADAS aerosol scattering		633	633	
Total water		871	871	
Heimann rad'mtr: SST/cloud top temp			393	
CCN/Alleviator for CCN		765	765	
PSAP aethelometer		621	621	
Filters (new system)	1753	1753	1753	
CO ('new' KFA)	285		285	
CN Counter	138	138	138	
Broad band radiometers (BBR)	90	90	90	Replaced by J radiometers
Ozone (new instrument)	656	656	656	
Peroxide (revamped instrument)	1867		1867	Estimate: may be 500 less
VACC	1955	1955	1955	May use partial fit only
2D-C cloud particle spectrum		173	173	
FSSP cloud droplet spectrum		403	403	
ICTP in-cloud temp			118	
SAFIRE IR-Vis radiation			255	
CVI counter-flow virtual impactor			1426	
Mass spectrometer			4830	
Nephelometer		736	736	
FWVS (H2O vapour)	112			
$J(NO_2)$	30		30	Replaces a BBR
$J(O^1D)$	50			Replaces a BBR
4-channel NO_{xy}	5915			Estimated power
Flask sampling	600			
HCHO	460			Estimated power
TDLAS	1250			To fit in 1997
PERCA	1725			To fit in 1997 - est. power
PAN	364			
Total ACSOE	17250	8893	18097	
TOTAL FIT	**23390**	**15369**	**24573**	
Total available power	21000	21000	21000	

A.4 SPECIAL TOPIC, STUDENTSHIP, AND SHIP/AIRCRAFT TIME AWARDS

CORE FACILITY:

A. ACSOE Core Facility
Professor S A Penkett (University of East Anglia)

SPECIAL TOPIC AWARDS:

1. **Construction of a Sensitive (4-channel) NO_y/NO_y Instrument for installation in the Meteorological Office C-130 Hercules Aircraft *(ACSOE-OXICOA)***
Professor S A Penkett (University of East Anglia)

2. **The Development and Deployment of an Airborne Peroxy Radical Chemical Amplifier (PERCA) *(ACSOE-OXICOA)***
Professor S A Penkett and Dr K C Clemitshaw (University of East Anglia)
and Dr M E Jenkin (AEA Technology)

3. **Studies of NO_3 and other Radical Chemistry in the Troposphere *(ACSOE-OXICOA)***
Dr J M C Plane (University of East Anglia)

4. **Measurements of Stable Trace Gases in ACSOE *(ACSOE-OXICOA)***
Dr G Nickless and Dr P G Simmonds (University of Bristol)

5. **Measurements of Individual NO_y Species in ACSOE *(ACSOE-OXICOA)***
Professor R M Harrison (University of Birmingham)

6. **Measurement of Individual NO_y Species and Total Non-methane Hydrocarbons *(ACSOE-OXICOA)***
Dr J N Cape (Institute of Terrestrial Ecology)

7. **Tunable Diode Laser Absorption Spectroscopy (TDLAS) NO_2 and HCHO Measurements on the MRF C-130 Aircraft *(ACSOE-OXICOA)***
Dr H M ApSimon (Imperial College, London)

8. **Measurement of Tropospheric OH and HO_2 in ACSOE using the FAGE Technique *(ACSOE-OXICOA)***
Professor M J Pilling and Dr D E Heard (University of Leeds)

9. **Ozone Lidar Programme during ACSOE *(ACSOE-OXICOA)***
Dr G Vaughan (University of Wales, Aberystwyth)

10. **Aircraft Measurements of Trace Species in the Free Troposphere *(ACSOE-OXICOA Modelling) Studentship***
Dr G Vaughan (University of Wales, Aberystwyth) and Dr G J Jenkins (Meteorological Office)

11. **Modelling in support of ACSOE Objectives *(ACSOE-OXICOA Modelling) Studentship***
Dr J A Pyle (University of Cambridge)

12. **Air-Sea Interaction Studies 1: S and N Cycles in the Marine Troposphere *(ACSOE-MAGE)***
Professor R M Harrison (University of Birmingham)

13. **Air-Sea Interaction Studies 2: A proposal to study Aerosol and Rainwater Chemistry as a component part of the ACSOE/MAGE Community Research Project *(ACSOE-MAGE)***
Dr T D Jickells (University of East Anglia)

14. **Air-Sea Interaction Studies 3: Measurement of Trace Gases, Air-Sea Exchange Transfer Velocity and Sulphur Isotopes as a component part of the ACSOE/MAGE Community Research Project *(ACSOE-MAGE)***
Professor P S Liss and Dr P D Nightingale (University of East Anglia)

15. **Air-Sea Interaction Studies 4: A Proposal to model the Chemistry of the Marine Boundary Layer as a component part of the ACSOE/MAGE Community Project *(ACSOE-MAGE Modelling) Studentship***
Dr J M C Plane (University of East Anglia)

16. **Air-Sea Interaction Studies 5: Measurement and Modelling of Homogeneous and Heterogeneous Nucleation in Marine Air during the Eastern Atlantic Experiment *(ACSOE-MAGE)***
Dr M H Smith (UMIST)

17. **Dimethyl Sulphide and its Oxidation Products at Mace Head: A Contribution to the 1996 ACSOE Eastern Atlantic Experiment *(ACSOE-MAGE)***
Professor C N Hewitt and Dr B M Davison (University of Lancaster)

18. **Cloud Processing of Aerosol - the Mountain Top Experiment *(ACSOE-ACE II)***
Dr J N Cape (Institute of Terrestrial Ecology)

19. **Cloud Aerosol Interactions in the Sub-Tropical North Atlantic *(ACSOE-ACE II)***
Professor T W Choularton (UMIST)

20. **In-Cloud Transformations of Dimethyl Sulphide and Related Compounds during the ACE-II Mountain Top Experiments *(ACSOE-ACE II)***
Professor C N Hewitt and Dr B M Davison (University of Lancaster)

21. **Studies of NO_3 and other Radical Chemistry in the Troposphere: A Contribution to a Study of Cloud Aerosol Interactions in the Sub-tropical North Atlantic *(ACSOE-ACE II)***
Dr J M C Plane (University of East Anglia)

22. **Modelling in support of ACSOE *(ACSOE-OXICOA Modelling)***
Dr JA Pyle (University of Cambridge)

23. **Cloud Aerosol Interactions in the Sub-Tropical North Atlantic (ACE-2) Data Analysis and Modelling *(ACSOE-ACE Modelling)***
Professor T W Choularton (UMIST)

24. **Modelling studies of sulphur/aerosol chemistry during ACSOE *(ACSOE-OXICOA-ACE-MAGE Modelling)***
Dr R Toumi (Imperial College, London)

25. **Box Model Studies in Support of Hydroxyl Measurements during ACSOE *(ACSOE-OXICOAModelling)* *Studentship***
Dr D E Heard (University of Leeds)

25. **A 3-D Modelling Study of the Tropospheric Ozone Budget within ACSOE *(ACSOE-OXICOA Modelling)* *Studentship***
Dr C E Reeves (University of East Anglia)

26. **Modelling the Photolysis of Ozone during ACSOE *(ACSOE-OXICOA Modelling) Studentship***
Dr R Toumi (Imperial College, London)

SEA TIME AWARDS (to date):

I. **ACSOE-MAGE: Dual Tracer Measurements of Air-Gas Exchange and Estimates of Biogas Fluxes in the Southern North Sea**
Dr RC Upstll-Goddard (University of Newcastle-upon-Tyne)

II. **ACSOE-MAGE: Eastern Atlantic Experiment**
Professor RM Harrison (University of Birmingham)

AIRCRAFT TIME AWARDS (to date):

A. **ACSOE-OXICOA: Cross Boundary Air Mass Characterisation Experiments (AMCHEX)**
Professor SA Penkett (University of East Anglia)

B. **ACSOE-OXICOA: Testing Atmospheric Chemistry in Anticyclones (TACIA)**
Professor SA Penkett (University of East Anglia)

C. **ACSOE-OXICOA: Vertical Profiles $N0_3$ Lifetime through the Troposphere (NITELIFE)**
Dr JMC Plane and Dr H Coe (University of East Anglia)

D. **ACSOE-OXICOA: Seasonal Vertical Profiles above Ground Based Sites (AMCHEX)**
Professor SA Penkett (University of East Anglia)

E. **ACSOE-OXICOA: N0xy Loss Experiment (LAGPRO)**
Professor SA Penkett (University of East Anglia)

F. **ACSOE-OXICOA: Air Mass Characterisation Experiments (AMCHEX)**
Professor SA Penkett (University of East Anglia)

G. **ACSOE-OXICOA: Chemical Processing during Long-Range Transport (LAGPRO)**
Professor SA Penkett (University of East Anglia)

H. **ACSOE-OXICOA: INITEST96/INTEST97 (Instrument Testing)**
Mr B Bandy and Mr S Baguitte (University of East Anglia)

I. **ACSOE-OXICOA: Test Flying of N0xy Instrument**
Professor SA Penkett (University of East Anglia)

J. **ACSOE-OXICOA: Oil Field Flux Experiments (INITEST/LAGPRO)**
Dr JN Cape (Institute of Terrestrial Ecology)

K. **ACSOE-OXICOA: Inverse Lagrangian Experiment (LAGPRO)**
Dr JN Cape (Institute of Terrestrial Ecology)

L. **ACSOE-OXICOA: Transport of Pollutants by Frontal Systems (AMCHEX)**
Dr G Vaughan (University of Wales, Aberystwyth)

M. **ACSOE-ACE: ACSOE-3 Flying for ACE-2 Experiments**
Professor TW Choularton (UMIST)

N. **ACSOE-ACE: Modification of CCN and Aerosol Size Distribution by Cloud Processing and the UK (MODCLOD)**
Professor TW Choularton (UMIST)

O. **ACSOE-MAGE: Measurement and Modelling of Homogenous Nucleation in Marine Air during the Eastern Atlantic Experiment**
Dr M Smith (UMIST)

A.5 DIRECTORY OF PIs, CORE GROUP AND CONSORTIA LEADERS

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A.6 ACSOE SCIENTIFIC STEERING GROUP

1 **Remit**

The Scientific Steering Group should provide integrated and coherent guidance and advice on science and management aspects of ACSOE.

2 **Terms of Reference for ACSOE SSG**

2.1 To advise the Programme Leader on the implementation of the ACSOE Science Plan, including the organisation and integration of the major scientific activities of ACSOE in line with the scientific aims of the programme.

2.2 To advise the Director of Science and Technology on:

- the allocation of resources within ACSOE (following external peer review of all grant applications by NERC Awards and Training Section);
- the requirements for major capital equipment and facilities, including aircraft and other platforms, computing and remote sensing.

2.3 To ensure effective liaison with the relevant national and international programmes and funding agencies.

2.4 To advise the Director S&T on the scientific progress of ACSOE and to report as required to Council, normally through the May meeting of Atmospheric Science and Technology Board

3 **Membership:**

Prof. S.A. Penkett	UEA	(Chairman, Programme & OXICOA Leader)
Dr R.A. Cox	UCamb	
Prof. T.W. Choularton	UMIST	(ACE Leader)
Prof. R.M. Harrison	UBirm	(MAGE/OXICOA)
Dr G. Jenkins	UKMO	
Prof. P.S. Liss	UEA	(MAGE Leader)
Dr J. Pearson	Shell	
Dr J.A. Pyle	UCamb	(ACMSU)
Dr W.T. Sturges	UEA	(Programme Manager, SSG Secretary)
Mr N.R. Collins	NERC	(ASTB)

Additional members may be co-opted as required for *ad hoc* Review Panels etc.

A.7 PARTICIPANT LIST

Beverley Allan,	University of East Anglia	OXICOA, MAGE, ACE
Dr Peter Allan	Rutherford Appleton Laboratory	Database (BADC)
Dr Andrew Allen	University of Birmingham	OXICOA, MAGE, ACE
Dr Helen ApSimon,	Imperial College	OXICOA, MAGE
Jonathan Baker	University of East Anglia	OXICOA, MAGE
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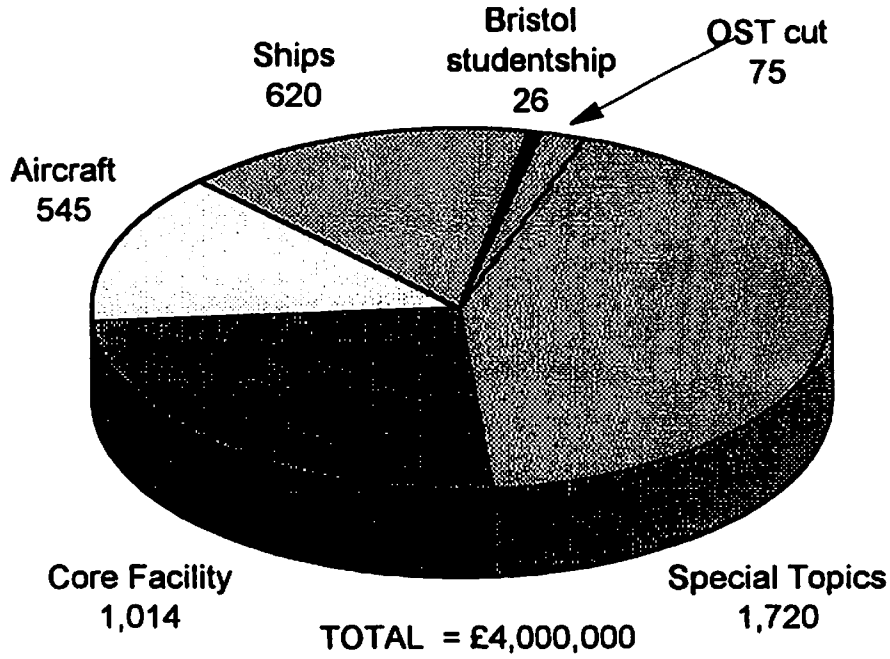
Stéphane Bauguitte	University of East Anglia	OXICOA, Coordinator, NO_{XY}
Karl Beswick	UMIST	ACE
Siân Bethan	University College of Wales, Aberystwyth	OXICOA
Dr Keith Bower	UMIST	ACE Coordinator
Carl Bradbury	UMIST	ACE
Dr David J. Brassington	Imperial College	OXICOA
Dr Wendy Broadgate	University of East Anglia	MAGE Coordinator
Rachel A. Burgess	University of East Anglia	OXICOA, ACE, MAGE, HCs
Dr Lucia Campos	University of East Anglia	MAGE
Dr. J. Neil Cape	ITE	OXICOA, ACE
Laura Cardenas	University of East Anglia	OXICOA
Lucy Carpenter	University of East Anglia	OXICOA
Prof. Tom W. Choularton	UMIST	ACE Consortium Leader
Nicola Clegg	Imperial College	OXICOA
Dr Kevin C. Clemitshaw	Imperial College / University of East Anglia	OXICOA
Dr Hugh Coe	University of East Anglia	OXICOA, MAGE, ACE
Mr Nigel R. Collins	Natural Environment Research Council	NERC
Edward B. Cooper	Southampton Oceanography Centre	NERC
Dr Tony Cox	University of Cambridge	ACSOE
David J. Creasey	University of Leeds	OXICOA
Wendy Davies	University College of Wales, Aberystwyth	OXICOA
Dr Brian Davison	University of Lancaster	MAGE, ACE
Mr Ken Dewey	Meteorological Research Flight	MRF
Dr Steve Dorling	University of East Anglia	OXICOA
Mathew Evans	University of Cambridge	OXICOA
Dr John Foot	Meteorological Research Flight	MRF
Dr Martin Gallagher	UMIST	ACE
Michael Geever	University College, Galway	Mace Head
Dr Stuart Gibb	Plymouth Marine Laboratory	MAGE
Dr Lesley Gray	Rutherford Appleton Laboratory	Database, BADC
Dr Lee Grenfell	University of Birmingham	OXICOA, MAGE
Prof. Roy M. Harrison	University of Birmingham	OXICOA, MAGE, ACE
Dr Dwayne Heard	University of Leeds	OXICOA
Professor Nicholas Hewitt	University of Lancaster	MAGE, ACE
Martin Hill	UMIST	MAGE
Professor Oystein Hov	Universitetet I Bergen	TACIA
Jonathan James	University of Birmingham	OXICOA, MAGE
Dr Mike E. Jenkin	National Environmental Technology Centre	OXICOA
Professor S. Gerry Jennings	University College, Galway	Mace Head
Dr Tim Jickells	University of East Anglia	MAGE
Dr Doug Johnson	Meteorological Research Flight	ACE, MRF
Dr Andrew Kaye	Meteorological Research Flight	NERC MRF
Mr Joss Kent	Meteorological Research Flight	MRF
Professor Dr. Dieter Kley	Kernforschungsanlage, Jülich	OXICOA
Dr Cliff Law	Plymouth Marine Laboratory	MAGE
Dr Kathy Law	University of Cambridge	OXICOA
Chunkey Lepine	Rutherford Appleton Laboratory	Database
Alastair C. Lewis	University of Leeds	OXICOA
Dr Paul Lightman	Imperial College	OXICOA, MAGE
Professor Peter S. Liss	University of East Anglia	MAGE Consort. Leader, ACE

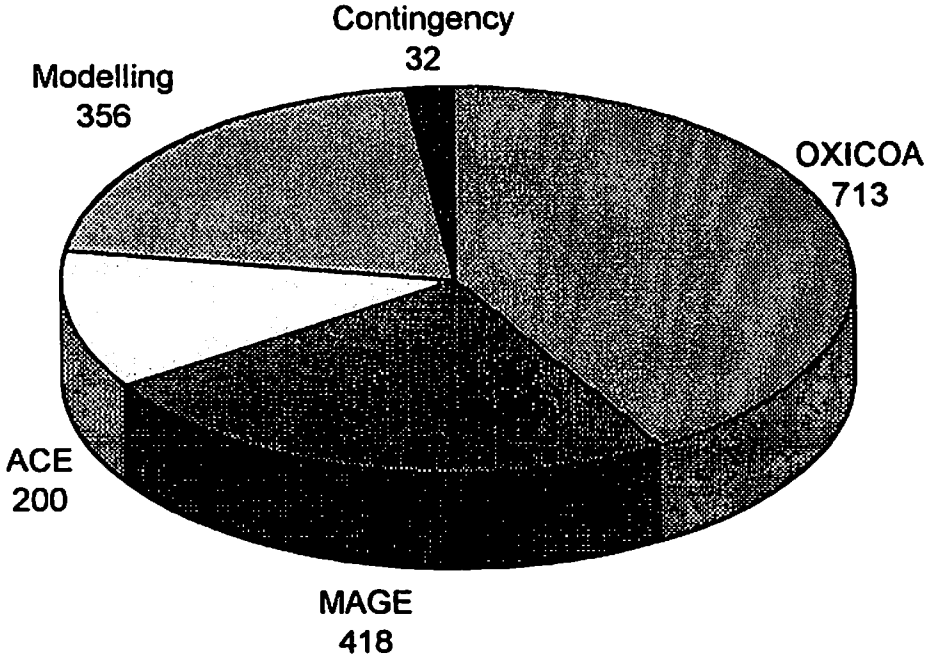
Sally Jo Locarnini	University of East Anglia	MAGE
Remi Losno	Universites Paris 7 et Paris 12	MAGE
Roy Lowry	BODC, BIOSTON Obsservatory	Database (BODC), MAGE
Dr Gill Malin	University of East Anglia	MAGE
Professor Fauzi Mantoura	Plymouth Marine Laboratory	MAGE
Dr Nicola McArdle	University of East Anglia	MAGE, ACE
Dr Tony Marsh	Imperial College	OXICOA, MAGE
Dr G. McFadyen	ITE	OXICOA, ACE
J.M. McQuaid	University of Leeds	OXICOA
Bill Miller	NERC Research Vessel Services	NERC, MAGE
Dr Paul Monks	University of Leicester	OXICOA
Dr Graham Nickless	University of Bristol	OXICOA
Dr Phil Nightingale	University of East Anglia	MAGE
Fiona O'Connor	University of Wales, Aberystwyth	OXICOA
Dr Colin O'Dowd	UMIST	MAGE, ACE
David Oram	University of East Anglia	OXICOA
Professor Nicholas Owens	University of Newcastle-upon-Tyne	MAGE
Mrs Marigold Penkett	University of East Anglia	ACSOE, Admin. Support
Prof. Stuart A. Penkett	University of East Anglia	ACSOE Programme Leader, OXICOA Consort. Leader
Professor Mike Pilling	University of Leeds	OXICOA
Dr John M.C. Plane	University of East Anglia	OXICOA, MAGE, ACE
Dr Ulrich Platt	University of Heidelburg	OXICOA
Dr John Pyle	University of Cambridge	OXICOA
Dr Claire Reeves	University of East Anglia	ACSOE, Database Manager
Dr Hannah Richer	Meteorological Research Flight	MRF
Léonie Robertson	University of Lancaster	MAGE
Nick Savage	University of East Anglia	OXICOA
P.W. Seakins	University of Leeds	OXICOA
Dr Dudley Shallcross	University of Cambridge	OXICOA
Dr Peter Simmonds	University of Bristol	OXICOA
Dr Mike Smith	UMIST	MAGE, ACE
Dr Gerry Spain	Mace Head Research Station	Mace Head
Dr Lucinda Spokes	University of East Anglia	MAGE
Dr William Sturges	University of East Anglia	ACSOE Programme Manager
David A. Tiddeman	Meteorological Research Flight	MRF
Dr Ralf Toumi	Imperial College	OXICOA
Dr Sue Turner	University of East Anglia	MAGE
Dr Rob Upstill-Goddard	University of Newcastle-upon-Tyne	MAGE
Dr Geraint Vaughan	University College of Wales, Aberystwyth	OXICOA
Prof. Andrew Watson	University of East Anglia	MAGE
Dr Martin Wells	UMIST	ACE
B.J. Whitaker	University of Leeds	OXICOA
Dr O. Wild	University of Cambridge	OXICOA
Stuart Yeatman	University of East Anglia	MAGE

A.8 FINANCE

ACSOE BUDGET (March 1996)
(in £1,000)



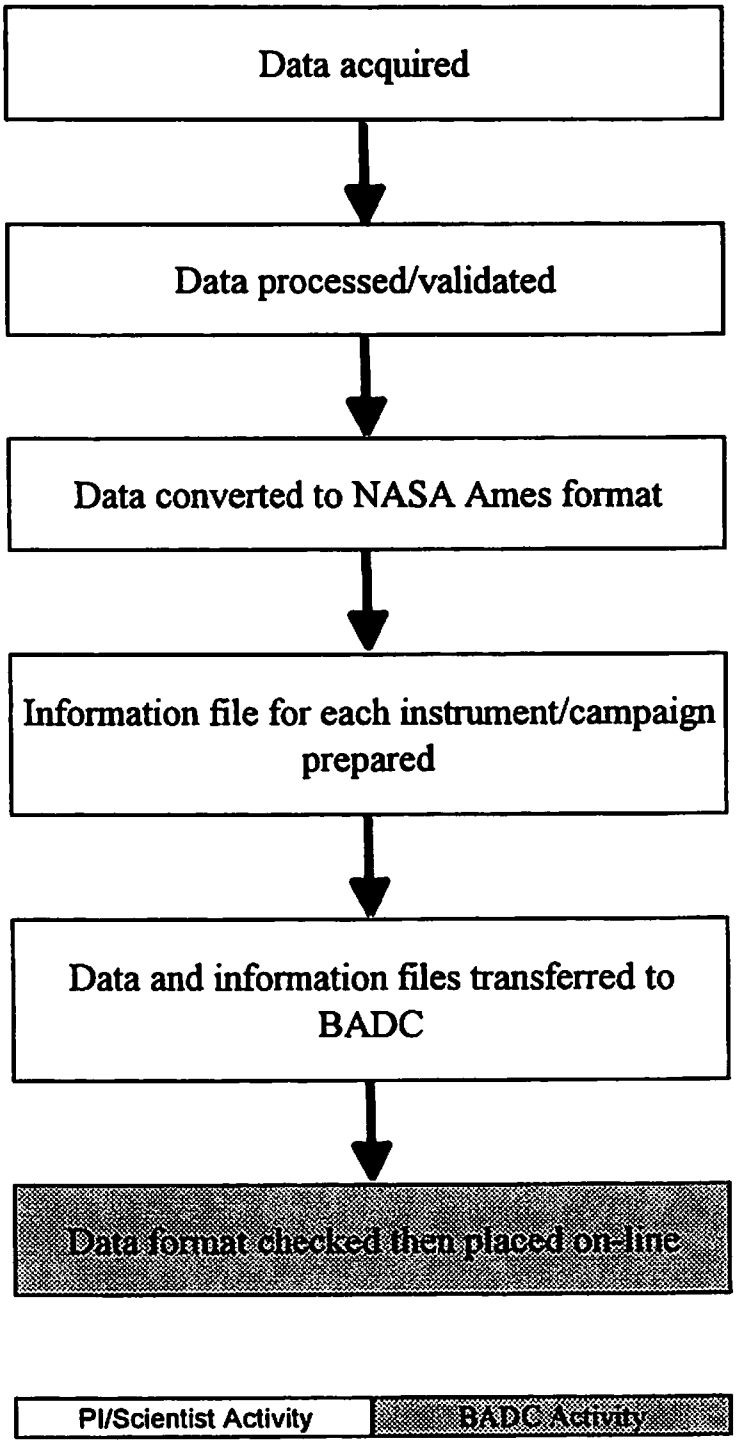
SPECIAL TOPIC AWARDS
(in £1,000)



A.9 DATA SUBMISSION PROCEDURE, PROTOCOL AND DEADLINES

Data Submission Procedure

Each PI is required by the Data Protocol to submit his/her data to BADC in order to encourage rapid dissemination of scientific results. To facilitate this, a Procedure has been set up ensuring that the appropriate information is attached with the data to enable it to be useful to other ACSOE scientists. Below is a simple flow chart indicating the major steps involved with steps 1-5 being carried out by the scientist. More detailed guidelines will be provided by BADC.



Data Protocol

The aims of the Protocol are: a) to encourage rapid dissemination of scientific results from ACSOE; b) to protect the rights of the individual scientists; and c) to have all the involved researchers treated equitably. These aims conflict at times, and it is hoped that the provisions of the protocol resolve these conflicts fairly. It is recognised that this cannot always be achieved to everyone's complete satisfaction; there are bound to be cases where individual interests clash with those of the ACSOE mission. Therefore to try to meet these aims, all PIs involved in ACSOE, in accordance with and on behalf of their co-investigators, must agree to abide by the following conditions:

(i) Preliminary data must be made available to other ACSOE scientists as soon as possible. (There are 2 advantages to quick release: a) planning of the future phases of the mission can be greatly improved, and b) scientific evaluation of the data can occur in a timely manner).

(ii) Any corrections or amendments to the preliminary data should be announced as soon as possible.

(iii) Validated data must be made available to other ACSOE scientists via the BADC by the submission date stipulated for each experiment in the ACSOE Implementation Plan.

(iv) Results of model studies using data acquired during ACSOE must be made available to other ACSOE scientists via BADC as soon as possible.

(v) It is each PI's responsibility to ensure that the data used in publications are the best available at that time.

(vi) All scientists involved in ACSOE are to have equal and complete access to measurements and model results produced during ACSOE.

(vii) If measurements or model results from other research groups within ACSOE are used in a publication, joint authorship must be offered. (This does not necessarily have to be accepted, particularly in cases where due credit and acknowledgement can be given in other, possibly more appropriate, ways).

(viii) Whilst the data is restricted from the public domain (see ACSOE Implementation Plan), each PI has the right to refuse to allow his/her work, whether measurement or calculation, to be used in a publication or presentation prior to the PI's own publication of that work.

(ix) Whilst the data is restricted from the public domain (see ACSOE Implementation Plan), no data should be transferred to a third party without the originator's consent.

(x) In the event of dispute the final decision rests with the ACSOE Scientific Steering Group.

Data Deadlines

EXPERIMENT	DATES	DATE FOR SUBMISSION OF DATA TO BADC #	DATE FOR RELEASE OF DATA TO THE PUBLIC DOMAIN
EASE 96	8 Jul - 9 Aug 96	31 Jan 97	1 Feb 2000
EASE 97	Mar - Jun 97	31 Jan 98	
C-130 FLIGHTS	Various	6 months after flight	2 years after Submission Date
OZPROF	Jun-Aug & Winter 96 & 97	6 months after measurement	2 years after Submission Date
LTERM	96, 97 & 98	31 Dec 98	1 Jan 2001
FIRETRAC	96, 97 & 98	31 Dec 98	1 Jan 2001
EAE 96	5 Jun - 4 Jul 96	31 Dec 96	1 Feb 2000
EAE 97	May 97	31 Jan 98	
ASGAMAGE	1-17 Oct 96	30 Jun 97	1 Jul 1999
NAE 98	Jun 98	31 Dec 98	1 Jan 2001
HILLCLOUD 96	23 Jun - 14 Jul 96	31 Dec 96	1 Aug 2000
HILLCLOUD 97	15 Jun - 31 Jul 97	31 Jul 98	

There may be an arrangement for some oceanographic data to reside at BODC. The same deadline will apply.

A.10 ACRONYMS

ACE	Aerosol Characterisation Experiment (ACSOE component of ACE-2)
ACE-2	Aerosol Characterisation Experiment (2)
ACRU	Atmospheric Chemistry Research Unit
ACMSU	Atmospheric Chemistry Modelling Support Unit
ACSOE	Atmospheric Chemistry Studies in an Oceanic Environment
ACSSG	Atmospheric Chemistry Scientific Steering Group
AEROCE	Atmosphere/Ocean Experiment
AGAGE	Advanced Global Atmospheric Gases Experiment
AMCHEX	Airmass Characterisation Experiment (OXICOA)
ASE	Air-Sea Exchange (EUROTRAC)
ASGAMAGE	Air-Sea Gas Exchange (contribution to MAGE)
ARASF	Atmospheric Research Airborne Support Facility
ASTB	Atmospheric Science and Technology Board (NERC)
BADC	British Atmospheric Data Centre
BAS	British Antarctic Survey
BL	Boundary Layer
BODC	British Oceanographic Data Centre
CCN	Cloud Condensation Nuclei
CFC	Chlorofluorocarbon
CMDL	Climate Monitoring Diagnostics Laboratory
CN	Condensation Nuclei
CCN	Cloud Condensation Nuclei
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DMS	Dimethylsulphide
DOAS	Differential Optical Absorption Spectrometer
DoE	Department of the Environment
EAE	Eastern Atlantic Experiment
EASE 96/97	Eastern Atlantic Spring/Summer Experiment 1996/97 (OXICOA)
ECMWF	European Centre for Medium-Range Weather Forecasting
EPICA	European Programme for Ice Coring in Antarctica
EU	European Union
EUROTRAC	European Experiment on Transport and Transformation of Environmentally relevant Trace Constituents in the Troposphere over Europe
FAGE	Fluorescence Assay by Gas Expansion
FIRE-TRAC	Firn and Ice Record of Trace Atmospheric Chemistry (OXICOA)
FREETEX	Free Troposphere Experiment
GAW	Global Atmospheric Watch
GC-MS	Gas Chromatograph / Mass Spectrometer
GDF	Great Dun Fell
HALOTROP	Halogen Chemistry in the Troposphere
HC	Hydrocarbon
HFC	Hydrofluorocarbon
HILLCLOUD	Hill Cloud Experiment (ACE)
HORACE	On-board computer of MRF C-130
IFMA	Instruments for Field Measurements in the Atmosphere Special Topic

IGAC	International Global Atmospheric Chemistry Project
IGBP	International Geosphere-Biosphere Programme
INDOEX	Indian Ocean Experiment
INITEST 96	Instrument Test in C-130
IPCC	Intergovernmental Panel on Climate Change
ITE	Institute of Terrestrial Ecology
ITOY	International Tropospheric Ozone Year
JGOFS	Joint Global Ocean Flux Study
LAGRANGIAN	Lagrangian Experiment (ACE)
LAGPRO	Lagrangian and Chemical Processing Studies
LIDAR	LIght Detection And Ranging
LOIS	Land Ocean Interaction Study
LTERM	Long-Term Measurements of Chemical Climatology (OXICOA)
MAGE	Marine Aerosol and Gas Exchange
MBL	Marine Boundary Layer
MODCLOD	Modification by Cloud Processing (ACE)
MOZAIC	Measurement of OZone by Airbus In-service airCraft
MRF	Meteorological Research Flight
MSA	Methanesulphonic Acid
NAE	North Atlantic Experiment (MAGE)
NARE	North Atlantic Regional Experiment
NASA	National Aeronautics and Space Administration
NERC	Natural Environment Research Council
NETCEN	DoE Data Centre
NITELIFE	Vertical Profiles of NO_3 Lifetime
NMHC	Non-methane Hydrocarbons
NOAA	National Oceanic and Atmospheric Administration
OCTA	Oxidising Capacity of the Tropospheric Atmosphere
OXICOA	The Oxidising Capacity of the Oceanic Atmosphere
OZPROF	Ozone Lidar Profiles
PAGES	Past Global changes
PAN	Peroxyacetyl nitrate
PERCA	Peroxy Radical Chemical Amplifier
PFC	Perfluorocarbon
PI	Principal investigator
PRICE	Peroxy Radical Intercomparison Exercise
PML	Plymouth Marine Laboratory
RVS	Research Vessel Services
SSG	Scientific Steering Group
TACIA	Testing Atmospheric Chemistry in Anticyclones
TDL/TDLAS	Tunable Diode Laser Absorption Spectrometer
TOASTE	Transport of Ozone and Stratosphere/Troposphere Exchange
TOR	Tropospheric Ozone Research
UEA	University of East Anglia
UCG	University College, Galway
UGAMP	UK Universities' Global Atmospheric Modelling Project
UMIST	University of Manchester Institute of Science and Technology

UNEP	United Nations Environmental Programme
UPS	Uninterruptible Power Supply
WAO	Weybourne Atmospheric Observatory
www	World-Wide-Web

A.11 MACE HEAD VISITING SCIENTIST GUIDELINES

The Mace Head site is host to a number of long-term projects. It is a major concern that new projects (whether long- or short-term) do not interfere with existing operations. To this end, the visiting scientist must submit a protocol describing the proposed project. The protocol must be fully detailed as to procedures, reagents and other materials used in addition to requirements for space, power and other site facilities. The protocol should be submitted well in advance of the proposed starting date so that it can be circulated to other site users for information purposes and comment and to allow time for the resolution of possible conflicts which might occur.

Restricted or undesirable chemicals/materials

Organic Compounds

The use of volatile organic compounds is generally undesirable although it is sometimes unavoidable. Where possible, they should be used off-site (e.g. for spiking rain samples) or confined to the cottage laboratory. Where appropriate, scrubbers should be used.

Currently, the use of alcohol's and acetone for cleaning purposes is permitted on-site. Where these are used as part of a sampling apparatus, a charcoal scrubber should be used.

Chloroform, methyl chloroform, carbon tetrachloride or any other chlorinated solvents are not permitted on-site under any circumstances.

Mercury

Liquid mercury is not allowed on site. This includes liquid mercury thermometers. In addition, instrumentation which emits gaseous mercury must have a charcoal scrubber on its exhaust (this is required by law in most countries).

CFCs/HFCs and Halocarbons

Refrigerators or freezers are not allowed on site. Air conditioning units may be used, subject to approval.

The use of spray cans on-site is not allowed unless the propellant is known and is acceptable. Sprays which are simply labelled "Ozone Friendly" or "CFC-free" without identification of the propellant are not acceptable.

The use of blown foam packaging is generally not acceptable. In most cases, it should be possible to use an alternative such as bubble-wrap. Where the use of blown foams is unavoidable, e.g. as part of a custom built instrument packing case, it is the responsibility of the visiting scientist to find out what the blowing agent is and to submit this information as part of the project protocol.

Effluent Disposal

Liquid effluent should not be disposed of on-site. Mace Head essentially has a domestic sewerage system which is not designed to take chemical waste. Unless specific arrangements are made on-site waste disposal should take place off-site. Gaseous effluent must be properly scrubbed, if deemed necessary.

Some General Recommendations

The AC power supply should be considered "dirty" and it can be assumed that high voltage spikes will occur daily. Although power cuts and brown-outs generally occur more frequently during the winter,

they can happen at any time. Any sensitive equipment should be protected by an uninterruptible power supply (UPS). (Limited UPS support will be provided by ACSOE for certain key instruments.) The majority of power cuts are quite short so a UPS with a backup capacity of 5-10 mins will very often be sufficient. Where a specific instrument procedure must be followed, a UPS of sufficient capacity should be installed. Obviously, instruments should be configured to shut down and restart automatically.

When selecting sampling materials (i.e. sample lines, filter holders, mounting brackets, nuts and bolts, etc.) bear in mind that the air is moist and salty. Stainless steel or monel, anodised aluminium, teflon and other plastics are recommended. Galvanised steel will eventually rust and is not recommended for long-term use. Brass fittings will oxidise quickly but may be OK in some circumstances where they are isolated from other metals. Where necessary, UV resistant material should be used. Plastics, such as HDPE, will eventually become brittle and crack due to exposure to UV, however they may last for one or two years, depending on the type used.

Space inside the building is limited and, in the case of EASE96 and 97, is almost fully utilised during ACSOE campaigns. Heat dissipation may be a problem, and ACSOE will provide limited air conditioning via portable a/c units.

ACSOE will provide central facilities for telephone (2 lines), Fax, U34 modem, Pentium computer with CD-ROM and TRAVAN tape backup, colour inkjet printer (HP-850), and photocopier (A4 paper and transparencies).