CSIRO

Division of Atmospheric Research

Research Report 1985 – 1988

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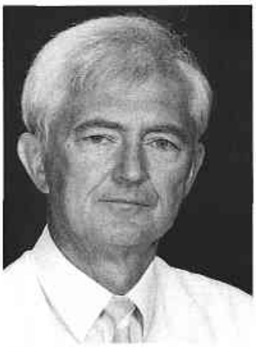
Contents

Foreword



The Chief of the CSIRO Division of Atmospheric Research, Dr G. B. Tucker

This research report is being issued at an auspicious time. The current popular and world-wide interest in atmospheric science is unique. A general awareness of the precious nature of our environment not only encompasses important specific topics such as acid rain, air quality and stratospheric ozone, it is now firmly focussed on climate — the synthesis of all atmospheric studies.

Over the last three years the Division of Atmospheric Research has experienced a remarkable increase in morale and in resources. Practically all the increased funding is from external sources and has been due to the enthusiastic advocacy by members of the Division of the skills resident here and the scientific achievements that contribute strongly to national objectives. In the past eighteen months increased external funding has significantly exceeded further cuts in Treasury funding and the growth being experienced at the Division contrasts markedly with the overall trend within CSIRO. A major expansion, of course, has occurred in greenhouse type research. However, this has been paralleled by strong scientific advances in drought prediction research, in aspects of remote sensing and in the application of laboratory, field, theoretical and computing skills to problems of atmospheric pollution.

The Division has been strongly involved in many national and international programs and is generally regarded as a leading agency in climate research, in atmospheric chemistry on both regional and global scales and in boundary layer studies. This report details work in these areas and describes other research achievements between 1985 and 1988.

Strong support for this resurgence of atmospheric science and the role of the Division in solving problems of major national relevance has been shown by many who are involved in one way or another with our activities. These include the Director of the Institute of Natural Resources and Environment; the Divisional Advisory Committee; the Australia and New Zealand Environment Council and associated State agencies; several Government departments, particularly the Department of Arts, Sport, the Environment, Tourism and Territories; the Commission for the Future and the Australian Conservation Foundation. Fair and sympathetic reporting from the media has contributed to the new sense of purpose and self-esteem that has spread throughout the Division.

It is a great pleasure to acknowledge the fine spirit and pride in achievement shown by all staff members.

G. B. Tucker
Chief of Division

November 1989

Overview

While the thrust of the Division's research effort has remained the same, there has been a redefinition of the four major research programs. Each program is made up of a number of research projects and the projects listed are current for July 1988. The new programs and component research projects are:

Global Atmospheric Change
Research seeks to discover why the chemistry of the atmosphere is changing, how it will change in the future and how our climate is influenced by these changes. The aim is to provide a predictive capability of atmospheric and climatic change and to put this in a specific Australian perspective.

- The mechanisms and causes of increases in non-reactive trace gases (carbon dioxide, methane and chlorofluorocarbons) in the global atmosphere
- Scientific support for the Cape Grim Baseline Atmospheric Pollution Station (CGBAPS)
- Chemical, physical and biological mechanisms regulating reactive gases and aerosols in the global atmosphere
- Studies of the dynamics and physics of global and regional climate change
- Studies of dynamical and physical mechanisms producing anomalous atmospheric circulations
- Climate impact and assessment

Atmospheric Pollution and Bushfire Meteorology
This program studies factors which influence air pollution and bushfires. The focus is on identifying sources of pollution and understanding the way in which it is formed, transported and dispersed. The aim is to assist industry and regulatory bodies which are concerned with atmospheric pollution and the implementation of control strategies.

- Theoretical and experimental studies of turbulent dispersion in the atmospheric boundary layer
- Air quality dynamics: research and applications
- Regional studies of visibility reducing aerosols and oxidant precursors in the Latrobe Valley
- Bushfire meteorology research

Remote Sensing
A precise understanding of the way solar radiation interacts with the atmosphere is essential to our understanding of many physical processes which determine the nature of our weather and climate. Remote sensing techniques are used to collect information about the earth's atmosphere, oceans, land and ice surfaces. The aim is

to use our improved understanding of these physical processes to provide accurate information for the management of the natural environment.

- Satellite data applications
- Commercialisation of CSIDA
- New instruments for meteorological satellites
- Development of new lidar technology for atmospheric research

Water Resources

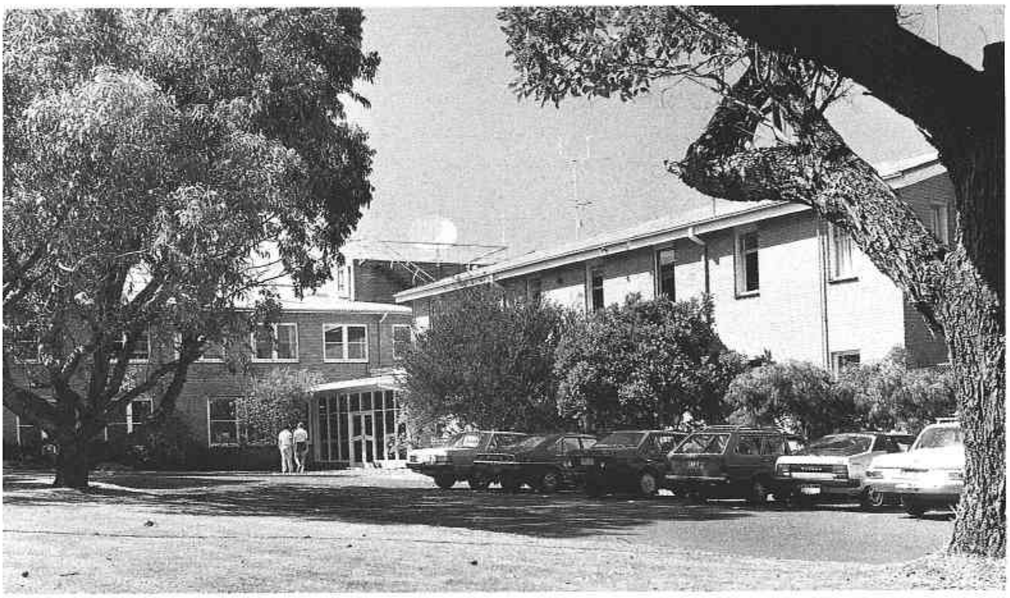
The program focuses on the way in which regional and global weather and climate processes influence the water budget. The aim is to provide practical means of forecasting droughts and to carry out research to improve our understanding of storms and rain-bearing systems.

- Drought studies
- Dynamics of mesoscale convective systems
- Surface moisture impact on climate
- Winter storms and cloud seeding, quantitative precipitation forecasting

Staff and finance

The Division of Atmospheric Research has some 115 staff, approximately two-thirds of whom are Research and Experimental Scientists. Expenditure in each of the financial years 1985–86, 1986–87 and 1987–88 was $6.2 million. In 1985–86 the non-appropriation funding was 3.5% of the total expenditure, but by 1987–88 this had risen to 11%. The Division is steadily increasing its level of funding from external sources and expects these sources to provide over 30% of its budget within two years.

The Division of Atmospheric Research



External funding

Project	Lead scientist	Grant
Dept of Foreign Affairs 1985–86 *Climatic effects on Australia of a nuclear war in the Northern Hemisphere*	B. Pittock	$140 000
Department of Science/Bureau of Meteorology 1985–88 *Baseline Air Pollution Station*	G. Pearman	$420 000
EPA(V) 1987–88 *Ambient organics*	I. Galbally	$15 000
EPA(V) 1987–88 *Non-methanic hydrocarbon study*	I. Galbally	$5 000
MMBW 1987–88 *Cloud seeding consulting contract*	A. Long	$230 000
MMBW 1987–88 *CSIRO F27 hire*	A. Long	$60 000
NERDDC 1987–88 *Meridional carbon isotope variations*	R. Francey	$13 500
NERDDC 1985–88 *Latrobe Valley Aerosol Visibility Study*	G. Ayers, J. Gras	$81 000
SEC(V) 1986–88 *Research Fellowship*	B. Sawford	$140 000
Victorian Department of Conservation, Forests and Lands (NBRU) 1987–88	T. Beer	$4 000
Wheat Industry Research Council 1986–88 *Gaseous nitrogen emission from irrigated wheat in South Australia*	I. Galbally	$20 000
Revenue earned by the Division		
Anemometer calibrations 1986–88		$35 000
CSIDA Images 1986–88		$50 000
Mass spectrometry analysis 1987–88		$5 000
Workshop/Conference funding:		
AVHRR Workshop 1986–87 COSSA		$5 000
Bureau of Meteorology		$10 000
CSIRO (Groundwater Research)		$3 000
Asia Australia Association via COSSA		$2 000
GAGE Meeting 1986–87 Bureau of Meteorology		$3 000
Aerosol Association of Australia		$1 000
Greenhouse 87 sponsorship 1987–88		$18 500

The Divisional Advisory Committee

In a move to ensure the Division's accountability and to strengthen the Division's support from outside CSIRO, Dr Tucker decided in 1983 to invite a number of prominent figures to serve on a Divisional Advisory Committee. The Committee meets twice a year and advises the Chief on policy and other matters. It also has a very important role in identifying the interests of the Australian community that may be furthered by the Division's research as well as suggesting the best way to make this work known to interested persons and organisations.

In July 1988 the Advisory Committee consisted of:

Mr Hal Holmes, Chairman
Chairman (retired), Monsanto Australia Limited

Mr Richard Llewelyn,
Manager, Research and Development, State Electricity Commission of Victoria

Mr Mike Lodge,
Deputy General Manager (retired), Board Member, Woodside Offshore Petroleum Pty Ltd

Dr Ian McPhail,
Director-General, Department of Environment and Planning, South Australia

Mr Alan Rainbird,
Deputy Secretary, Commonwealth Department of Aviation

Dr Brian Tucker,
Chief of Division of Atmospheric Research

Mr Bob Chynoweth, Observer
M.P., Federal Member for Dunkley

Dr Willem Bouma, Secretary to the Committee
Division of Atmospheric Research

Highlights 1985 – 1988

The Atmospheric Pollution and Bushfire Meteorology Program has shown significant progress in all areas. In particular, a new laboratory facility (a large convection tank) is in the process of being constructed and installed. Amongst other highlights for this program was the successful completion of the Latrobe Valley Air Shed Study in which CSIRO collaborated with the State Electricity Commission of Victoria (SECV) and the Environment Protection Authority of Victoria (EPAV). Theoretical studies on plume dispersion in the convective boundary layer compliment the Latrobe Valley field work. An offshoot of the Airshed Study, a National Energy Research, Development and Demonstration

Council (NERDDC) supported project on visibility problems and ozone precursors in the Valley, was carried out by the Division's atmospheric chemists.

There have also been several developments relating to the Global Atmospheric Change Program. These include significant scientific achievements in trace gas studies such as improved precision in CO_2 measurement and the successful analysis of air trapped in Antarctic ice, contributions to the understanding of the newly discovered "ozone hole" and a burgeoning gas container project which has commercial implications. A scenario of climate change for Australia was developed to assist the preparation for the Greenhouse 87 Conference which is referred to below.

An exciting project in the Remote Sensing Program was the design and development of a prototype atmospheric pressure scanner while collaboration with the Rutherford Appleton Laboratory in the UK continued on the development of the Along Track Scanning Radiometer. A novel activity for the Division has been to provide the motivation and the business plan for a new company to design, engineer and market satellite reception and analysis systems. Commercialisation of products from satellite data continues to bring revenue to the Division.

The drought component of the Water Resources Program has been highly successful scientifically in establishing an association between continental scale drought and two different sea surface temperature anomaly patterns in the Pacific Ocean. Indeed, a novel theoretical approach is being developed to determine that pattern of anomalous sea surface temperature which produces the largest response in the atmospheric circulation. A second feature of this program has been the Division's involvement in field experiments on mesoscale weather phenomena such as convective storms over northern Australia and frontal systems over south-eastern Australia.

During 1987 the Division put a great deal of effort into organising the Greenhouse 87 Conference. The two major objectives were:

- to have experts in the various potential impact areas assess the impacts of climate change of the kind possible due to greenhouse warming.
- to communicate to the wider scientific and engineering community the current status of the greenhouse theory.

About 90 scientists and engineers took up the challenge early in 1987 and prepared 57 papers for presentation at the meeting. The papers were of a high standard and, after refereeing and selection, they were used to produce the Greenhouse 87 Conference Proceedings, which were almost ready for publication by the end of the reporting period.

Global Atmospheric Change

Introduction

Changes in the chemical composition of the atmosphere are occurring both regionally and globally. Locally these changes have effects on visibility and the quality of the air we breath. At a global level there is now strong evidence that these changes are likely to bring about significant climatic modifications as a result of the greenhouse effect. Some will be beneficial, others will not.

Reliable predictions of these changes will be of great benefit to the Australian community. This requires an understanding of why the chemistry of the atmosphere is changing, how it will change in the future and how the climate system, at both the global and regional level, is influenced by these changes.

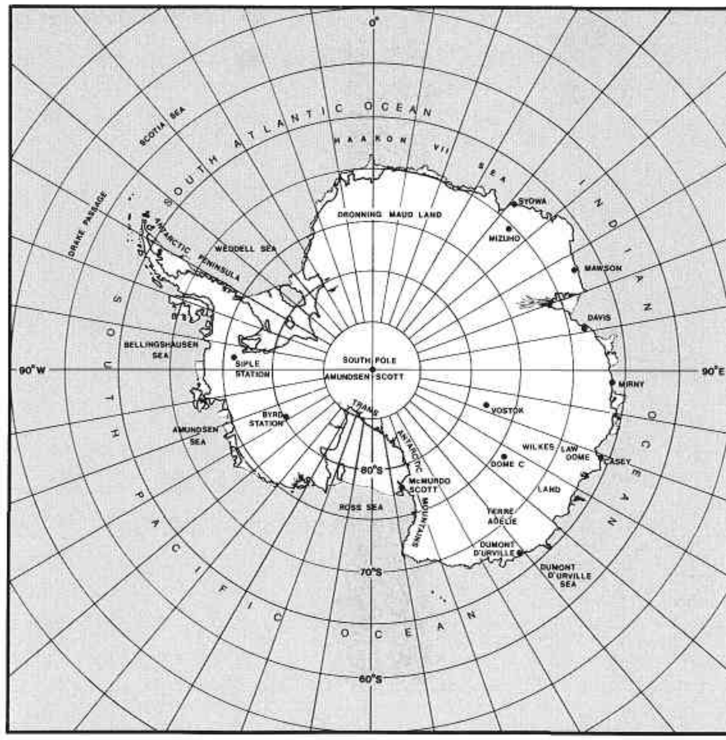
The objectives of the Global Atmospheric Change Program are to predict and understand the mechanisms responsible for alterations in the chemical and physical character of the atmosphere. Projects involve a combination of theoretical numerical modelling and observations which will improve the understanding of the budgets of key climatically important trace gases and aerosols.

Carbon dioxide

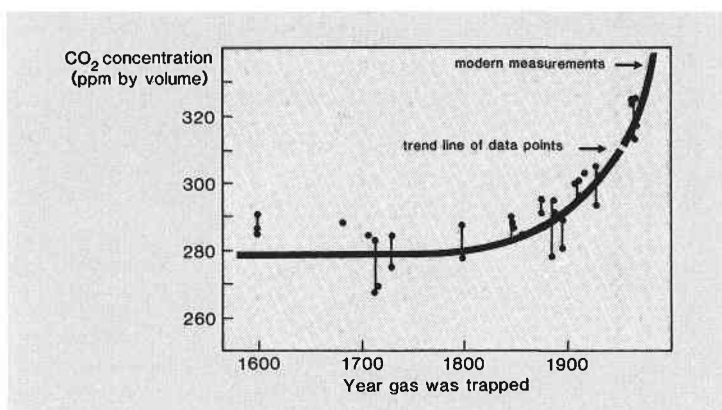
Confident predictions of how future carbon dioxide emissions will affect the concentration of this gas in the atmosphere rely on an accurate model of carbon dioxide pools and their interactions. For accurate modelling the carbon dioxide concentration prior to 1850 must be known. It was at this time that industrialization and forest felling began to have an impact.

Air bubbles trapped in polar ice from as long ago as the 17th century have been analysed by Division scientists in collaboration with scientists from the Australian Antarctic Division. It has been discovered that, prior to 1800, the carbon dioxide concentration was essentially constant at about 280 ppm.

To carry out the analysis, ice which has been drilled from the Antarctic is crushed under vacuum. The released air is then dried and condensed in a trap cooled by liquid helium, and transported to the CSIRO laboratories. Gas chromatography is used to determine the abundance of carbon dioxide as well as nitrous oxide and methane.



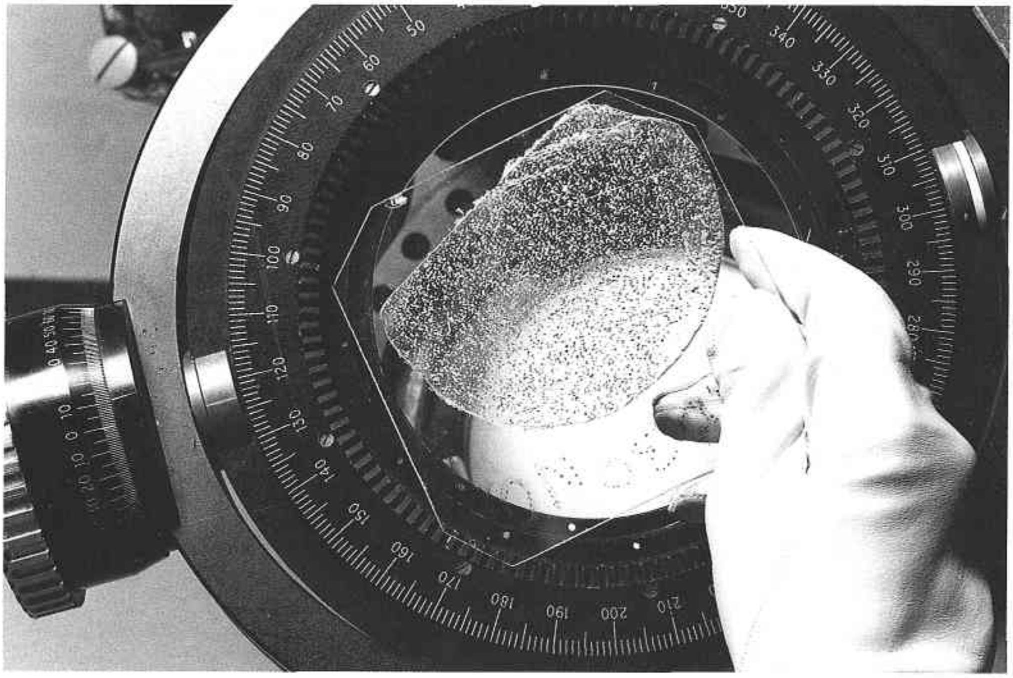
Map of Antarctica showing major features, ice-coring sites and stations



Carbon dioxide concentrations determined from air trapped in Antarctic ice-cores

Impact of plants on carbon dioxide

The Division of Atmospheric Research operates a high quality sampling network measuring the carbon-13/carbon-12 isotope ratio in atmospheric CO_2 from clean air sites. This is used to identify the portion of the CO_2 which has experienced photosynthesis in land plants, including that from fossil fuels. An unanticipated bonus from this project, which is funded by NERDDC and has logistic support from CGBAPS (Cape Grim Baseline Air Pollution Station), NOAA/GMCC (Geophysical Monitoring For Climate Change) and the Australian Antarctic Division, is the first reliable global data on the oxygen-18/



A cross-section through an ice-core from Law Dome, Antarctica.

oxygen-16 isotope ratio. It has been found that the oxygen isotope ratio exhibits strong systematic behaviour with both latitude and season as well as with the El Niño – Southern Oscillation phenomenon.

The most likely explanation is that this is also due to the action of green plants, 90% of which grow in the tropics and the northern hemisphere. Measurements indicate that between 30% and 50% of the total atmospheric CO_2 interacts with leaf water each year. It is dissolved and oxygen atoms are exchanged with the water before the carbon dioxide is again released. While within the plant, the CO_2 molecule encounters the enzyme carbonic anhydrase which ensures rapid exchange of one of its constituent oxygen atoms for an oxygen atom from one of the plant's water molecules.

Both the signature of the ground water oxygen-18 content (lower from the poles and continent interiors) and the shift of the ground water oxygen-18 due to evaporation from leaves, is reflected in the atmosphere carbon dioxide oxygen isotope values. The effects are most marked in the northern hemisphere.

At a time when serious questions are emerging about the way fossil fuel carbon dioxide is being removed from the atmosphere, the research is providing a fresh look at a gross exchange aspect of the carbon cycle which has not previously been observed. Variations in this data carry information on zonally averaged plant activities. At the least, the oxygen isotope ratio in CO_2 promises to be an unusual tracer of atmospheric transport.