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Cabinet Submission 6363 - Australian response to the greenhouse effect and related climate change - Decision 12416

Copy No. 43

C A B I N E T M I N U T E

Canberra, 3 April 1989

No. 12416

Submission No. 6363 - Australian Response to the Greenhouse Effect and Related Climate Change

The Cabinet agreed that:-

(a) a strong commitment is required to address the greenhouse issue both nationally and internationally;

(b) a comprehensive strategy addressing greenhouse issues be adopted comprising a co-ordinated core research program (on regional climate modelling) plus a dedicated research grants scheme (for implementation in 1990-91) and support for development of national and international responses;

(c) funds be provided of $1.039 million in 1988-89 and $6.752 million in 1989-90, with those amounts to include staff and support costs;

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CABINET-IN-CONFIDENCE

No. 12416 (Contd)

(d) a National Greenhouse Advisory Committee be established to provide expert advice on greenhouse research issues, including priority areas and objectives for further research, and that the Committee be serviced by the Department of Arts, Sport, the Environment, Tourism and Territories (DASETT);

(e) Commonwealth action on national greenhouse issues be co-ordinated by an inter-agency committee chaired by the Department of the Prime Minister and Cabinet;

(f) the Prime Minister issue a press release along the lines of that at Attachment A to the Submission; and

(g) appropriate reference to the national research program on greenhouse related climate and environment changes also be made in the science policy statement to be delivered in May 1989.

2. The Cabinet noted that:-

(a) agreement to sub-paragraph 1(c) above will require additional ASL (CSIRO 4 in 1988-89 and approximately 30 in 1989-90 (outside ASL controls), DASETT 2 in 1988-89 and 10 ASL in 1989-90 and the Bureau of Meteorology 5 ASL in 1989-90), with details to be settled with the Minister for Finance; and

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(b) the Minister for the Arts, Sport, the Environment, Tourism and Territories would report back to Cabinet before the end of 1989 on further action required to address greenhouse climate change issues, including funding requirements for 1990-91 and 1991-92.

M. Codd

Secretary to Cabinet

CABINET-IN-CONFIDENCE

FOR CABINET

Submission No. 6363

Copy No. 43

Title

AUSTRALIAN RESPONSE TO THE GREENHOUSE EFFECT AND RELATED CLIMATE CHANGE

Minister

Senator the Hon Graham Richardson, Minister for the Arts, Sport, the Environment, Tourism and Territories; The Hon Barry Jones, MP, Minister for Science, Customs and Small Business; The Hon Stewart West, MP, Minister for Administrative Services

Purpose/Issues

To respond to Cabinet's request (Minute No 11674 of 4 August 1988) on options for enhancing Australian research into "greenhouse" climate change and to enable Australia to respond quickly to possible changes in the environment resulting from increasing levels of greenhouse gases in the atmosphere.

Relation to existing policy

The Prime Minister has undertaken to provide additional research funds if required (House of Representatives, 3.11.88). The 1988 ALP Platform states additional research and policy development is required.

Sensitivity/Criticism

Greenhouse related climate change is a major global environmental issue. It is essential that the Government has a response strategy for Australia.

Legislation involved

Nil

Urgency: Critical/significant dates

The climatic effects in the Australian region must be identified now. We must develop responses and protect our interests internationally.

Consultation: • Ministers/Depts consulted

A-G's, DCS & H, Defence, DEET, Finance, DFAT, DILGEA, DPIE, PM and C, DT & C, Treasury, ASTEC.

• Is there agreement?

No, see co-ordination comments at Attachment G

Timing/handling of announcement

Office of Government Information and Advertising has been consulted. Release of press statement by the Prime Minister along the lines of Attachment A.

Cost

ASL:	Fin Yr (—) 88/89	Fin Yr (—) 89/90	Fin Yr (—) 90/91
	$1.039m	$6.752m	Resources from
DASETT	2	10	1990/91 onwards to be
BOM	---	5	subject of a further
CSIRO	4	approx 30	Cabinet submission

Human activities, especially rates of population growth, burning fossil fuels, agriculture and deforestation are leading to growing concentrations of CO_2 and other "greenhouse" gases (oxides of nitrogen, CFCs, methane) in the atmosphere. There is widespread (even if not universal) scientific agreement that this will cause global warming by retaining a higher proportion of the sun's heat. In turn, sea levels will rise, patterns of rainfall, storms and cyclones will change (for more detailed information see Attachment B).

2. There is increasing international concern about the greenhouse effect and related climate changes. There is also increasing domestic concern. Cabinet recognised this when it requested options to enhance Australian research. To avoid long term deleterious social, economic and environmental effects, Australia must:

(a) accelerate its research efforts to understand the implications of the greenhouse effect for Australia's climate; and

(b) develop long term strategies to minimise the damage caused by these changes.

3. Australian greenhouse related research was surveyed by the Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT) in 1988. Some research is being undertaken by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology (BOM). However, there is little other specific "greenhouse research" (see Attachment C). Australia's research program must be accelerated if we are to understand the effects of the greenhouse phenomenon in the southern hemisphere generally and specifically on the Australian climate and environment.

4. International action on greenhouse issues has recently become focused through an Intergovernmental Panel on Climate Change (IPCC), established jointly by the World Meteorological Organisation (WMO) and the United Nations Environment Programme (UNEP) in 1988. The United Nations General Assembly and the OECD, among other international fora, are also addressing greenhouse and climate change matters.

5. Unless Australia participates in these deliberations, we risk having foisted upon us policies which will prejudice our international and domestic economic interests in agriculture,

forestry, transport, energy and manufacturing etc.

6. Most international research into the greenhouse effect derives from and focuses upon the northern hemisphere. Australia is one of the few countries in the southern hemisphere capable of undertaking the necessary research and playing a leading role in the development of international strategy.

7. Regionally, New Zealand, Japan and the Republic of Korea have expressed interest in collaborating with Australia on greenhouse issues.

CONSIDERATION OF ISSUES

8. Australia must:

(a) develop regional climate models;

(b) predict regional climate changes;

(c) identify consequent environmental and socio-economic impacts;

(d) ensure that international research takes into account southern hemisphere concerns;

(e) participate in international research programs such as the World Climate Research Programme and the International Geosphere-Biosphere Programme (IGBP);

(f) formulate policy responses to these changes; and

(g) formulate policy responses to reduce the build-up of greenhouse gases.

We cannot effectively assess greenhouse impacts or formulate policy responses without a predictive capacity, which we lack.

9. Current support for greenhouse research is inadequate:

(a) Australian Research Council funding is insufficient for greenhouse research. The Council cannot fund non-educational institutions (eg CSIRO and BOM);

(b) CSIRO has diverted $2m from other projects but cannot further reallocate appropriated funds without damaging its efforts in other equally high priority areas;

(c) BOM established the National Climate Centre from within existing resources in 1983, and has committed maximum possible effort to the climate issue since the establishment of the World Climate Programme in 1979. BOM's climate networks and data banks must be upgraded if it is to meet climate monitoring requirements in the 1990s. It cannot divert funds

to strengthen its research;

(d) other Government research programs (eg administered by the Departments of Primary Industries and Energy and Health and Community Services) address greenhouse issues only indirectly.

10. Furthermore, greenhouse research must be co-ordinated if Australia is to develop an effective strategy.

STRATEGY

11. We propose the following research strategy (set out at Attachment D and supplemented by Attachments E and F):

(a) fund an accelerated program of modelling of regional climate changes by CSIRO and BOM (annual funding of $3.462m (with $0.405m in 1988/89) plus one off expenditure on capital equipment of $1.670m); and

(b) establish a National Greenhouse Advisory Committee to provide expert scientific advice to Government on greenhouse issues generally and, in particular, advice on priority areas for further greenhouse research (basic science, impacts and responses) and set objectives for a dedicated research grants scheme, with a view to having a scheme operational in 1990/91. The Committee would be serviced by DASETT. Annual administrative costs of the Committee, including establishment, salaries and on costs for the secretariat are $0.086m in 1988/89 and $0.634m in 1989/90. (Funding from 1990/91 onwards will be the subject of a further submission; however, it is proposed at this stage that the grants scheme be $1.5m in 1990/91 rising to $3.0m in 1991/92 with annual administrative costs for the Committee and scheme of $0.714m).

This strategy is designed to complement the science initiatives agreed to in Minute No.12289 of 6 March 1989 and a National Climate Program being developed by BOM, in consultation with CSIRO and DASETT, and others.

12. This will permit us to develop policy and administrative initiatives (funding of $0.148m in 1988/89 and $1.006m in 1989/90 - with anticipated funding of $1.006m in 1990/91 and $0.589m in 1991/92) to address the causes and impacts of the greenhouse effect within Australia and to participate

effectively in major international greenhouse activities. An inter-agency committee (sponsored by DASETT and BOM and chaired by DASETT) will co-ordinate greenhouse issues and ensure liaison with bodies such as DPIE and DFAT, having important responsibilities for aspects of policy formulation. Co-operation with the States will continue using existing Commonwealth/State mechanisms such as ministerial councils.

13. As this is a global problem Australia must represent southern hemisphere interests in international fora. Specific funding is necessary for the WMO/UNEP IPCC (Australian input to be co-ordinated jointly by BOM and DASETT), the UNEP Climate Impact Studies Programme, and the IGBP in particular (funding of $0.100m in 1988/89 and $0.280m in 1989/90 - with anticipated funding of $0.250m in 1990/91 and $0.050m in 1991/92), details at Attachment D.

OPTIONS

14. There are two options:

(a) continue the existing low level, ad hoc approach to research, impact assessment and response development. In essence, this ignores the problem and rests upon the assumption that a solution acceptable to Australia will be found internationally. Such inaction will be politically damaging; or

(b) implement the program outlined in paragraphs 11-13 above and detailed in Attachments D, E and F.

15. Action is required now:

(a) internationally, governments are recognising the need for a co-ordinated response. Heads of Government met in The Hague on 11 March. (The resultant declaration, which Australia signed, calls for urgent international action to combat any further warming of the atmosphere.) There are two further international ministerial meetings later this year. Australia must act, and be seen to be acting, with the same urgency. We must be able to press our considerable trade and domestic interests as international action proceeds;

(b) as greenhouse research develops internationally the demand for specialists is increasing. Australia will be unable to compete for their services unless

greenhouse research resources are vastly enhanced; and

(c) politically, the Federal Government must be seen to be taking decisive and positive action on greenhouse issues (similar to our action in implementing ozone protection measures).

EMPLOYMENT CONSIDERATIONS

16. The program proposed will require approximately 30 extra staff for CSIRO (outside ASL controls), 5 for BOM, and 10 for DASETT (12 from 1990/91), to be discussed with the Minister for Finance.

FINANCIAL CONSIDERATIONS

17. The proposed program (to be appropriated to DASETT) will cost $1.039m in 1988/89 and $6.752m in 1989/90. (Ongoing funding from 1990/91 will be the subject of a further cabinet submission - with anticipated costs of $6.932m in 1990/91 and $7.815m in 1991/92.) Details of costings are summarised in Attachment D.

COMMUNICATION

18. We propose that the Prime Minister issue a media statement announcing the research initiative (as outlined in Attachment A) as soon as possible after the decision is taken. The strategy outline (at Attachment A, Appendix 1) primarily suggests themes for responses to media or other follow-up inquiries and does not envisage a major campaign. A longer-term education campaign to raise community awareness of the greenhouse issue and gain support for Government activities in the area will be submitted to the Ministerial Committee on Government Information and Advertising for approval. It is envisaged that such an educational campaign will include brochures, school kits and similar material. It is also likely to recommend further greenhouse conferences.

RECOMMENDATIONS

19. We recommend that Cabinet:

(a) agree that a strong commitment is required to address the greenhouse issue both nationally and internationally with co-ordinating responsibility to be with the Minister for the Arts, Sport, the Environment, Tourism and Territories;

(b) agree to a comprehensive strategy to address greenhouse issues comprising a co-ordinated core research program (on regional climate modelling) plus a dedicated research grants scheme (for implementation in 1990/91) and support for development of national and international responses;

(c) agree to expending $7.791m (which includes staff and support costs) during 1988/89 and 1989/90:

1988/89	$1.039m
1989/90	$6.752m

(d) note that the following additional resources will be required in subsequent years (including staff and support costs):

1990/91	$6.932m
1991/92	$7.815m

(e) agree to establishing a National Greenhouse Advisory Committee to provide expert advice on greenhouse issues, including priority areas and objectives for further research (to be serviced by DASETT);

(f) agree that Commonwealth action on greenhouse issues be co-ordinated by an inter-agency committee sponsored jointly by DASETT and BOM and chaired by DASETT;

(g) note that agreement to recommendation (c) will require additional ASL (CSIRO 4 in 1988/89 and approximately 30 in 1989/90 (outside ASL controls), DASETT 2 in 1988/89 and 10 ASL in 1989/90 and BOM 5 ASL in 1989/90) with details to be settled with the Minister for Finance;

(h) note that the Minister for the Arts, Sport, the Environment, Tourism and Territories will report back to Cabinet before the end of 1989 on further action required to address greenhouse climate change issues, including funding requirements for 1990/91 and 1991/92; and

(i) agree to the Prime Minister issuing a press release along the lines of Attachment A.

Graham Richardson	Barry Jones	Stewart West
29 March 1989	29 March 1989	30 March 1989

ATTACHMENT A

DRAFT MEDIA RELEASE

GOVERNMENT ANNOUNCES $7.8 MILLION GREENHOUSE STRATEGY

Government support for a national research program on greenhouse related climate and environment changes was announced today by the Prime Minister.

$7.8 million will be provided during 1988/89 and 1989/90 for research and policy support. A National Greenhouse Advisory Committee of up to six experts will be appointed to provide expert scientific advice to the Government on greenhouse issues. A key task for the National Greenhouse Advisory Committee will be to provide advice on priority areas for further greenhouse research (basic science, impacts and responses) and set objectives for a dedicated research grants scheme, with a view to the scheme getting underway in 1990/91. The Committee will also promote public understanding of greenhouse issues.

The Prime Minister said 'The greenhouse issue is one of the most severe environmental crises facing Australia and the world. Research into the greenhouse effect is crucial. Without it Australia will not be able to identify and adapt to environmental changes caused by the greenhouse effect. A national greenhouse research program is part of this Government's commitment to protect our environment.'

The Government would provide $5.54 million during 1988/89 and 1989/90 to CSIRO and the Bureau of Meteorology as part of the national greenhouse research program.

As part of the national greenhouse research program the Government will support the World Climate Impact Studies Programme being undertaken by the United Nations Environment Programme and will also examine the desirability of establishing a comprehensive national climate program linked into the World Meteorological Organisation World Climate Programme and the Second World Climate Conference in 1990. Funds will also be provided to the Academy of Science to assist the International Geosphere-Biosphere Program. This program studies the interactive physical, chemical and biological processes that regulate the total earth system.

These initiatives will assist Australia's active participation in international work on greenhouse issues, including the development of policy responses to reduce the continuing build-up in the atmosphere of greenhouse gases, and to deal with the consequences of possible climate and sea level changes.

The Prime Minister said 'Ongoing funding requirements for the greenhouse strategy for 1990/91 onwards will be considered by the Government later this year.'

MEDIA STRATEGY OUTLINE

Because the media statement deliberately does not attempt to suggest the research program is a solution to the greenhouse effect or to dress up the program as a major strategy (either of which claims could lead to media and public criticism) the primary communication strategy is not to undertake a proactive follow-up campaign.

There will be media interest and, as a result it is recommended that when Ministers respond to requests for interviews, talk-back appearances, etc, the following points be borne in mind:

1. The research will be practical and people-oriented, eg:

- research to predict the likely climate changes in particular areas
- research on what the possible effects of the climate changes may be:
  - what will the effects be on agriculture: will farming areas need to change crops/farming techniques; how will weeds/pests be affected;
  - will present storm water drainage and dam systems cope;
  - will soil erosion and salinity problems increase;
  - will coastal erosion increase.

2. The extent and effects of greenhouse climate change need to be more reliably predicted to prevent bad planning.

   Knee-jerk reactions now based on the recent scenarios could be very expensive (eg much more stringent building regulations for both residential and commercial properties). We need to be more certain exactly what action is required to ensure money and effort are not wasted. The parallel between the proposed research and the value of Census data for future planning could be mentioned.

3. The research is not the first or only thing being done - ozone protection measures are being implemented.

4. The research will contribute to the global body of knowledge on the subject and will help ensure Australian dimensions are taken into account when international or regional organisations are considering their responses to the problem.

5. The trade and economic aspects of the greenhouse issue should be played down as emphasis on them might lead to criticism that the Government is catering to sectional, moneymaking interests rather than protecting the quality of life of all Australians.

Questions may also be asked about action to reduce greenhouse gas emissions. The following points should be drawn upon:

- The countries who are major sources of greenhouse gas emissions (particularly CO_2) are in the Northern Hemisphere (USA, Western Europe, Eastern Bloc countries, industrial developments in China will compound the problem).

- Australian emissions are very small in comparison (assessed at about 1% of world total) - unilateral reductions by Australia would have no impact of any consequence on global emissions.

- Concerted international action is required.

- This is already underway and Australia is actively involved:

  - the UN Intergovernmental Panel on Climate Change is currently examining possible policy responses to reduce the continuing build-up of greenhouse gases

  - a Law of the Atmosphere convention was discussed at a meeting in Canada on 20-21 February

  - we have pushed for energy efficiency and conservation through research and development, thereby reducing emissions, to be high priority for the International Energy Agency.

- Within Australia, the Government is placing increasing emphasis on energy consumption; attention is being given to conservation, energy efficiency, greater use of renewable energy sources and R & D that will reduce emissions per unit of energy:

  - in the context of the greenhouse gas debate these issues are being pursued through the National Energy Consultative Council and the Australian Minerals and Energy Council;

  - under the National Energy Research Development and Demonstration Program there has been a significant level of funding for research on the environmental effect of energy production and use ($16m on 103 projects over the last 10 years).

- The guidelines and priorities for grants were amended earlier this year to generate greater focus on greenhouse related research (the total National Energy Research, Development and Demonstration Program amounts to $34m in 1988/89).

THE GREENHOUSE EFFECT

KEY FACTS

1. The atmospheric concentration of several gases is increasing fast - levels of carbon dioxide, the most important greenhouse gas, are expected to increase 30 percent in the next 50 years.

2. The build-up of greenhouse gases could increase the Earth's surface temperature by between 1.5 and 4.5°C by the year 2030:

   (a) this will have a major effect on climate - during the last Ice Age, the Earth's temperature was only about 5°C colder than it is now;

   (b) in northern latitudes, winters will be shorter and wetter, summers longer and drier; subtropical regions will become even drier than they are now; tropical ones even wetter;

   (c) these changes will have substantial but unpredictable effects on agriculture and natural ecosystems; and

   (d) as the oceans warm up and expand, sea levels will rise, leading to severe flooding over low-lying land.

3. Climatic changes of this type will lead to large regional changes in soil moisture, increased desertification, coastal flooding and erosion, salinity problems, storm damage and serious disruption to coastal settlements and activities.

4. These changes will be substantial and are likely to occur randomly. There will be increased climate variability and disruption well before 2030.

IMPACTS

5. The changes will have major environmental and socio-economic impacts for Australia. Sectors likely to be affected include:

   (a) <u>Agriculture</u>

   A warmer climate is likely to move the areas suitable for growing specific crops, such as wheat, towards the poles. If soils in these areas are poorer, yields will fall. Marginal agriculture - as practised, for example, in the drought-prone Sahel - will probably suffer most because of difficulties in adapting to the new conditions.

   Changes in agriculture will, in turn, produce cascade effects throughout society, altering the viability of farming, agricultural employment, commodity prices, and patterns of world trade.

b) Natural ecosystems

Changes in natural ecosystems will include expansion of grassland and desert areas with forested areas shrinking and moving polewards. Problems such as soil erosion could become more acute.

(c) Urban infrastructure

A warmer climate might make some cities unbearably hot. A wetter or drier climate will affect water use and long-term planning, perhaps making large reservoirs or other projects useless long before their normal 50-year lifetime had elapsed.

(d) Ports and coastal communities

As the oceans expand, sea levels will rise causing flooding of low-lying areas. While richer nations can afford to protect themselves (as the Dutch have done for centuries) poorer nations will have no choice but to lose large areas of precious land to the sea.
Most of Australia's population is located on or near the coast. Possible impacts range from extensive commercial and personal property damage, to disruption to shipping, trade, fishing and loss of beaches.

(e) Health

Tropical diseases will become more widespread, eg malaria and dengue fever, and mortality of the aged in extreme weather events will increase.

(f) Energy

International remedial action, eg moves away from fossil fuel usage, could have significant effects upon the Australian economy.

6. Some of the problems discussed above already affect many countries. Global warming will exacerbate them, dislocating communities, disrupting trade, generating urgent aid demands, and causing international tensions and conflicts.

7. Without detailed research it will be impossible to formulate responses to the greenhouse effect or to minimise its impact upon our environment and economy.

8. Government planning and private decision making has long assumed climate stability. Western societies in particular, are locked into industrial and agricultural practices and lifestyles which generate greenhouse gases.

9. Fortunately some problems which flow from the greenhouse effect are already under study eg land degradation, coastal management, population pressures.

10. Action is underway or proposed internationally to:

(a) use energy better;

(b) reduce fossil fuel use;

(c) encourage reforestation and discourage land clearing;

(d) develop laws for protection of the atmosphere;

(e) control the production and use of ozone depleting substances.

More detailed information is contained in the United Nations Environmental Program paper which follows.

UNITED NATIONS
ENVIRONMENT PROGRAMME

UNEP Environment Brief No 1

the changing atmosphere

Chemical pollution is changing the structure of the Earth's atmosphere, threatening to alter the climate and expose human populations to higher levels of dangerous ultraviolet radiation. This publication, the first in a series of UNEP briefing documents, summarizes what is known about the two major effects involved: the build-up of greenhouse gases in the atmosphere, and damage to the ozone layer.

Key facts

The greenhouse effect

- the atmospheric concentration of several gases is increasing fast ... levels of carbon dioxide, the most important greenhouse gas, are expected to increase 30 percent in the next 50 years
- this build-up of gases is likely to increase the Earth's surface temperature by between 1.5 and 4.5 °C by the year 2030
- this would be sufficient to have a major effect on climate ... during the last Ice Age, the Earth's temperature was only about 5 °C colder than it is now
- in northern latitudes, winters would be shorter and wetter, summers longer and drier ... sub-tropical regions might become even drier than they are now, and tropical ones even wetter
- these changes would have major but unpredictable effects on agriculture and natural eco-systems
- as the oceans warmed up and expanded, sea levels would rise, leading to severe flooding over low-level land
- there is an urgent need for international action to minimize the future greenhouse warming and its social effects

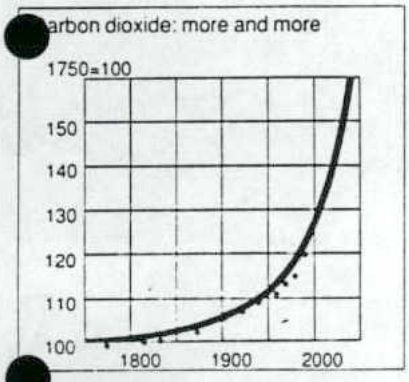
The ozone layer

- chemicals produced by industrial activity are interfering with the way ozone is created and broken down, threatening to reduce its concentration in the upper atmosphere
- because ozone filters out much of the Sun's ultraviolet radiation, human populations may soon be exposed to higher levels of a potentially dangerous form of radiation
- overall, ozone levels have not yet fallen – though measurements made during the Antarctic spring reveal that levels there have dropped 40 percent in just a few years
- scientists predict that, if chemicals continue to be produced at current rates, ozone levels in the upper atmosphere will fall by a few percent during the first half of the next century
- this could lead to increased skin cancer and eye disease, smaller crop and timber yields, and damage to ocean ecology
- a convention to protect the ozone layer has been signed by many states but has yet to come into force ... further international action is planned to restrict the production and use of the most seriously implicated chemicals

The greenhouse problem

The atmosphere that surrounds the Earth plays a critical role in maintaining even temperatures on the Earth's surface. Like the glass in a greenhouse, the atmosphere absorbs some of the long-wave radiation emitted by the Earth, and radiates energy back at the Earth. If the atmosphere were not present, temperatures on the Earth would be much lower than they are.

But industrial activity is changing the atmosphere's structure. As gases like carbon dioxide are produced and released into the atmosphere, they absorb more of the Earth's radiation, and return more of it back to the Earth. This energy, which would otherwise escape harmlessly into space, is already increasing the Earth's surface temperature, though so far by only small amounts (about 0.5 °C over the past 120 years).



Carbon dioxide is the most important of the greenhouse gases, and is produced primarily when fossil fuels are burnt to provide power. Levels of carbon dioxide in the atmosphere have already increased by some 25 percent since the Industrial Revolution; they are expected to increase by a further 30 percent in the next 50 years.

Many other gases also have a greenhouse effect. These include nitrous oxide (laughing gas), methane, ozone and chemicals used in refrigeration and other industries called chlorofluorocarbons (CFCs for short). The concentrations of these gases in the atmosphere are much lower than that of carbon dioxide but they are increasing, and many of them produce a very strong greenhouse effect. Scientists calculate that over the next half century or so the temperature rise produced by increasing concentrations of carbon dioxide will be matched by the effect of the other greenhouse gases. The carbon dioxide effect, in other words, will be doubled.

How much is the temperature likely to rise? By making assumptions about how much of each gas is likely to be released into the atmosphere, and feeding this information into computers that can model the atmosphere's behaviour, scientists can make rough estimates of what is likely to happen. Current predictions are that the greenhouse effect will amount to between 1.5 and 4.5 °C by the year 2030. Because the oceans take a long time to warm up, however, not all this increase will actually happen by 2030 – about half it will occur by then, the other half following in the ensuing decades.

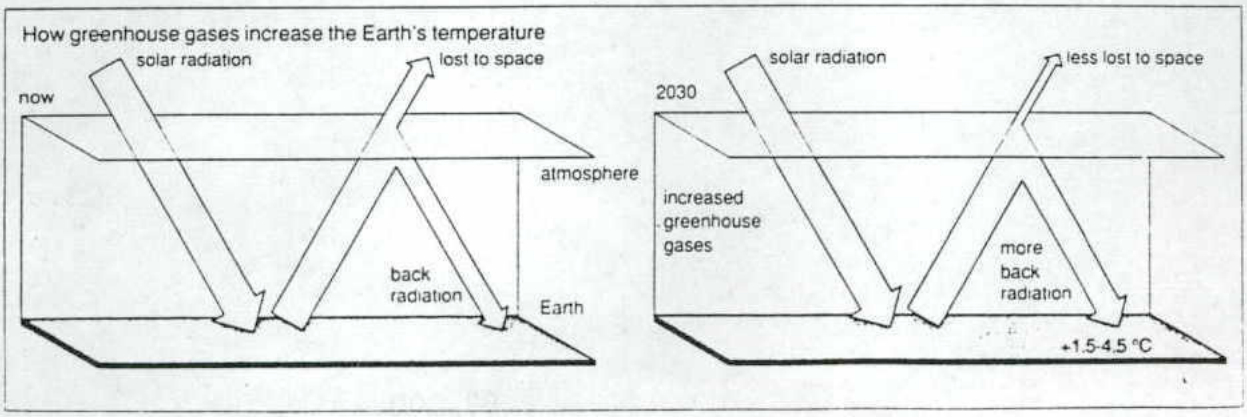
Even these apparently low figures will be enough to have a major effect on climate. Temperatures averaged over the whole globe over a year disguise what can happen locally in different seasons. Though the Earth's average temperature was only about 5 °C colder than now during the last Ice Age, it was very much colder in some places in some seasons.

What could happen to Washington

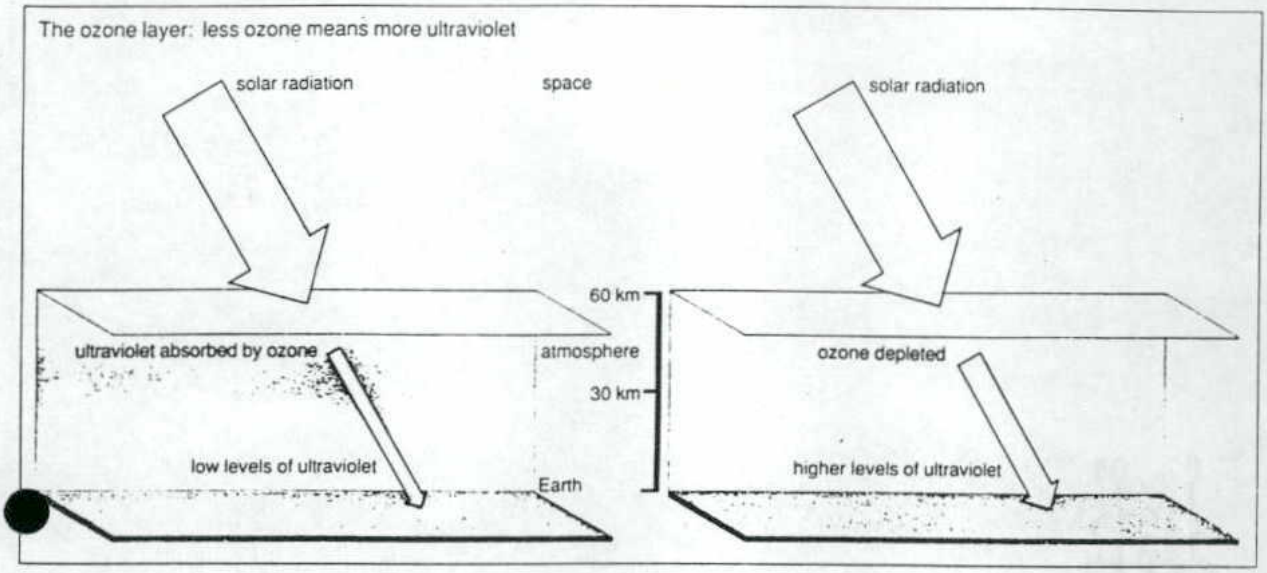
If carbon dioxide levels doubled, cities such as Washington DC could become very much warmer. The number of days a year in which the temperature exceeded 38 °C could rise from one to about 12; the number of days when the thermometer topped 32 °C could rise from 35 to 85 a year. The number of nights during which temperatures remained above 27 °C, could increase from an average of less than one a year to as many as nineteen.

Similarly, an average temperature rise of only 3 °C could mean increases of more than 10 °C at high latitudes in some seasons. In temperate zones, winters would tend to be shorter and warmer, summers longer and hotter.

Rainfall would also be affected. Evaporation rates would increase and overall rainfall would rise by an estimated 7-11 percent a year. Temperate winters might be wetter, and summers drier. The tropics would also become wetter but the sub-tropics, already dry, could become drier still.



Ozone: the umbrella against the ultraviolet



Ozone, a gas composed of three oxygen atoms, surrounds the Earth like a delicate veil, protecting the planet and its inhabitants from the direct gaze of the Sun. Ozone is our umbrella against the ultraviolet. Were it not present in the atmosphere, lethal levels of ultraviolet radiation from the Sun would reach the Earth's surface.

Ozone is found up to heights of about 60 km. It is most dense 20-25 km up but even here only one molecule in 100 000 is ozone. If all the ozone were collected at the Earth's surface, it would form a layer only about 3 mm thick. But because there is so little of it, and because its presence is so important, small changes in ozone concentrations could have dramatic effects on life on Earth.

Ozone is produced naturally, from oxygen, high in the atmosphere. Natural forces also break it down, with the result that the gas is constantly being created and destroyed. The speeds at which these reactions occur determine how much ozone there is in the atmosphere. And these speeds can be greatly influenced by chemicals in the atmosphere which act as catalysts in the reactions, speeding them up without themselves being destroyed.

Several chemicals used in or produced by industry greatly affect the speed at which ozone is broken down. These include the chlorofluorocarbons (CFCs) which are used as the propellants in aerosols, in refrigeration technology, as foam-blowing agents in the plastics industry and as solvents in electronics. Other gases that speed up the breakdown of ozone include nitrous oxide, and those containing chlorine, fluorine and bromine.

In trying to work out what will happen to ozone levels in the future, scientists must first make predictions about how fast chemicals like the CFCs and nitrous oxide will be produced in the future. They must then make models of how these chemicals react with ozone, and with one another, and estimate future ozone levels, at different heights and at different times in the future.

The latest results of this work suggest that ozone levels will fall by a few percent during the first half of the next century– although increases in CFC emissions could cause more than a 10 percent fall in ozone. Measurements of the total amount of ozone in the atmosphere show that levels have not changed appreciably as yet – though small changes do seem to be occurring at particular heights, with low level ozone concentrations increasing, and high level ones decreasing. There have, however, been dramatic changes over the Antarctic (*see box*).

Changes of a few percent in future ozone levels would be enough to let substantially more ultraviolet radiation reach the Earth's surface. Because ozone affects the Earth's heat balance in a number of ways, climate could also be affected by changes in ozone concentrations.

Ultraviolet radiation is responsible for sunburn, snow blindness, eye damage, skin cancer, and the ageing and wrinkling of skin. It affects plant growth, slowing down photosynthesis and delaying germination in many plants, including trees and crops. Algae are particularly sensitive to ultraviolet radiation, raising fears that damage to the ozone layer could upset marine ecology and lower fish populations.

The hole in the Antarctic's ozone

Measurements of ozone levels above the South Pole in the spring reveal that levels have fallen by 40 percent since 1957. Most of the decrease has occurred since the mid-1970s. These changes occur only during the Antarctic spring. Although they are limited mainly to the South Pole area, the effect can be detected as far north as 40°S. No one understands why these changes are occurring, or whether they could herald similar changes over wider areas.

What could happen ...

The greenhouse effect and ozone depletion are not completely separate problems. Ozone changes will affect climate, and carbon dioxide changes will influence ozone depletion. How are these changes likely to affect human society over the next half century?

Three separate effects are involved: climatic change, abnormally fast plant growth caused by high levels of carbon dioxide in the air, and increased levels of ultraviolet radiation.

Consequences of climatic change

The most obvious effect of climatic change will be on agriculture. A warmer climate is likely to move the areas suitable for growing specific crops, such as wheat, towards the poles. If soils in these areas are poorer, yields will fall. Marginal agriculture – as practised, for example, in the drought-prone Sahel – will probably suffer most because it will be unable to adapt easily to new conditions.

Changes in agriculture will, in turn, produce cascade effects throughout society, altering the economic viability of farming, agricultural employment, commodity prices, and patterns of world trade. There will also be widespread changes in natural eco-systems, with grassland and desert areas expanding, and forested areas shrinking and moving polewards. Problems such as desertification and soil erosion could worsen.

> ***"In the 300 years or so that have encompassed the agricultural and industrial revolutions, man has begun to replace nature as the engine of climatic change."***
>
> **Mostafa K. Tolba,**
> Executive Director, UNEP
> Villach Conference, 1985

A warmer climate might make some cities unbearably hot. A wetter or drier climate would also have major effects on water use and long-term planning, perhaps making large reservoirs or other projects useless long before their normal 50-year lifetime had elapsed.

As the oceans expanded, sea levels would rise causing flooding of low-lying areas. While richer nations could afford to protect themselves – as the Dutch have done for centuries – poorer nations might have no choice but to lose large areas of precious coastal land to the sea.

Plants would grow faster and larger

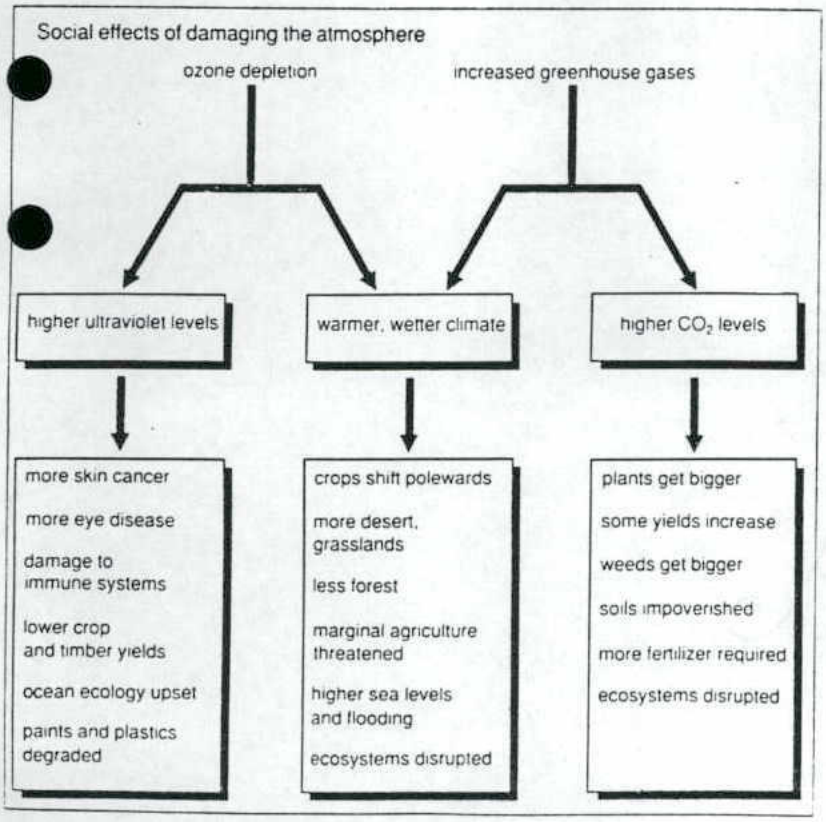
Because carbon dioxide is a natural fertilizer, most plants would grow larger and faster in a higher carbon dioxide world. At first sight, this might be thought beneficial because yields of major crops might increase. While this might be true, there would be many complicating effects: weeds would also get bigger, plants would be less rich in nitrogen and perhaps more susceptible to pests, and soils might become rapidly empoverished as a result of having to sustain high rates of plant growth.

In addition, natural eco-systems would be disrupted, with unpredictable results, as some species adapted easily to the new conditions while others dwindled or died out.

How dangerous is the ultraviolet?

Higher levels of ultraviolet radiation would have a number of major effects on society. Skin cancer - already the most common form of cancer in man - would become even more common, possibly even including the most lethal form, melanoma. Eye diseases would increase, and the ability of the body's immune system to cope with infections might be impaired. The yields of many crops could fall because ultraviolet radiation slows down many aspects of plant growth.

Plastics are also affected by ultraviolet radiation, and the lifetimes of many commonly used synthetic materials could be shortened. They might have to be renewed more frequently than in the past, at great economic cost. In addition, ozone depletion is likely to lead to more smog in cities.



... as the Earth gets warmer

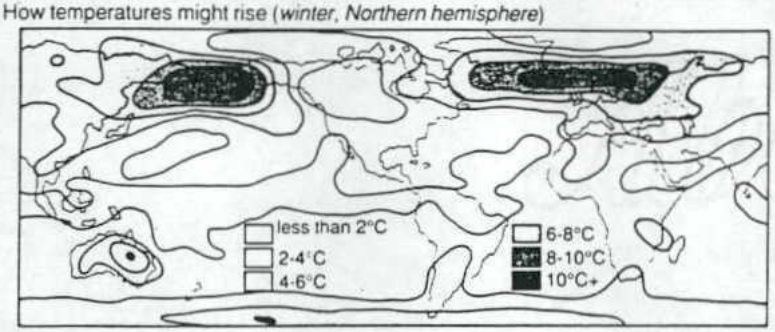
The Earth's climate has not varied by more than 1 or 2 °C in the past 10,000 years. The warming expected in the next 50 years will thus exceed any climatic change experienced in human history.

Models of the Earth's climatic system are not yet sufficiently reliable to predict exactly how a given change in average temperature will affect the different regions of the Earth. But, as the map on the right shows, they do give an indication of what might happen, with large temperature changes occurring in the high latitudes, particularly in the the world's major grain growing areas.

While warmer temperatures speed crop growth, they do not necessarily lead to higher yields: muggy conditions, for example, provide ideal breeding grounds for pests and diseases. Because agriculture is generally well adapted to existing climatic conditions, any major change is likely to prove disruptive rather than beneficial. This would be particularly true where crops are farmed on marginal land.

One climatic model suggests that greenhouse warming could cause a temperature increase of 3.4 °C and an increase in rainfall of 18 percent in some parts of Canada. This would lower wheat production by 25 percent, resulting in a fall in employment and gross domestic product.

How temperatures might rise (*winter, Northern hemisphere*)



Natural eco-systems would also be disrupted, with grasslands and deserts expanding in area, and forested areas growing smaller. The mix of plants in rangelands would alter, with unknown consequences for the stock grazing them.

Climatic change might also exacerbate existing problems such as desertification, drought and soil erosion. Ecological hazards such as floods, storms and forest fires might become more common, and warmer winters could enable more pests to survive winters in which they would previously have perished.

The world water cycle is likely to be profoundly influenced by the greenhouse warming, with rainfall increasing in many areas but with soils becoming drier as evaporation rates increase. All this would have a major effect on surface water run-off, and many dams, reservoirs and hydro-electric schemes might become useless. Planning would become impossibly difficult if the climate began to change fast.

How much would sea levels rise?

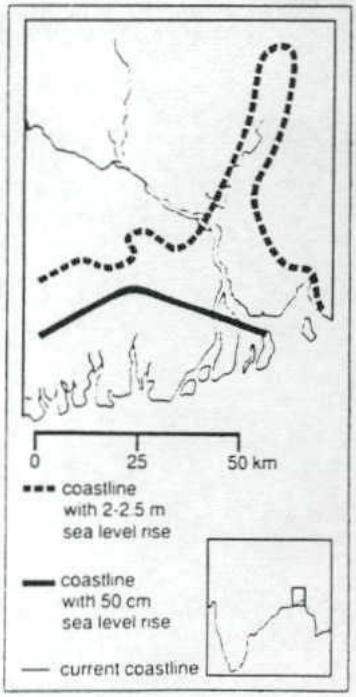
One of the main dangers of a warmer climate is flooding from rising sea levels. However, the greenhouse effect is not expected to melt the Antarctic ice to any great extent; this would require temperature rises of some 20 °C and take several centuries.

Nor is the greenhouse effect likely to cause the glaciers on the west of Antarctica to slip into the sea (an event that would cause sea levels to rise by some six metres). On the contrary, the volume of Antarctic ice could *increase* as a result of a small global warming because of the increased snowfall that would occur.

However, as the oceans warm up, they will expand. Scientists calculate that this expansion could cause a rise in sea levels of between 20 and 140 cm if the average temperature increases by between 1.5 and 4.5°C; a temperature rise in the middle of this range could increase sea levels by about 80 cm, more than enough to flood huge areas of unprotected coastal land.

Nearly one-third of all human beings live within 60 km of a coastline. A rise in sea level of even half a metre could therefore have profound effects on habitation patterns, causing many people to move and many of the world's most important cities and ports to come under threat of flood.

Adapting to rising sea levels will be easier for rich countries, which are likely to be able to afford elaborate sea defences, than for poor ones.



Maps right show how far the sea would invade Bangladesh with a 50 cm rise (top) and a 2.0-2.5 m rise (bottom)

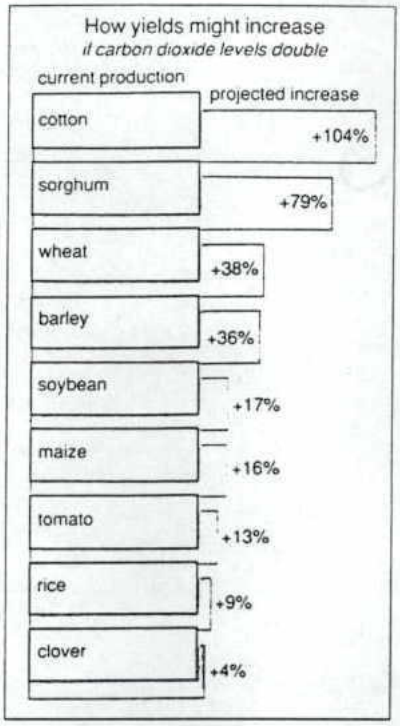
... plants get bigger

Because carbon dioxide is a natural fertilizer, plants will grow faster and larger in a higher carbon dioxide world. If carbon dioxide levels double– as they may do by later in the next century– the yields of many crops, and weeds, could increase by an average of about a third.

Plants have widely differing responses to increased carbon dioxide so it is difficult to predict what effects this could have on agriculture. Yields of some crops could even double while those of others changed very little.

Response depends on how a plant photosynthesizes. Plants that produce intermediary chemicals with three carbon atoms, the C_3 plants, respond well; those that produce intermediaries with four carbon atoms, the C_4 plants, much less so.

Of the world's 20 major food crops, are C_3 plants. The other four– maize, sorghum, millet and sugarcane– are C_4 plants, whose yields would not be expected to increase greatly. Unfortunately, three of these are the staple foods of most of sub-Saharan Africa, where food is already in short supply.



While increased yields would be beneficial in many areas, this would not be true in the United States, the EEC countries and Japan; here over-production is already agriculture's principal problem. Further yield increases would lower prices and subject farmers to increasing economic pressure.

Bigger plants with larger yields could raise other problems, too. Unless larger amounts of expensive fertilizer were used, the soil might well become impoverished as it struggled to provide the nutrients required by an increased crop cover.

... and the ultraviolet increases

If ozone levels are depleted by a few percent early in the next century, there will be increased levels of a tion of the spectrum known as -B on the Earth's surface. UV-B causes skin cancer and eye disease in man, slows down plant growth, is lethal to marine algae and breaks down the chemical structure of nts and plastics.

Currently, between 10 and 30 percent of the Sun's UV-B reaches the Earth's surface. If ozone levels were to fall by 10 percent, the amount of UV-B reaching the Earth would increase by about 20 percent.

Worldwide, about 100,000 people die from skin cancer every year – and UV-B is implicated in most cases of skin cancer. In the United States, the National Academy of Sciences has estimated that each 1 percent depletion of ozone would increase the incidence of skin cancer by 2 percent. On this basis, a 3 percent reduction in ozone would produce some 20,000 more cases of skin cancer in the United States every year.

Other medical effects are harder to quantify: more UV-B will increase eye disease, skin ageing and wrinkling, and probably impair the body's ability to cope with infections in general.

Some 200 species of plants have been tested for sensitivity to UV-B, and about two-thirds of them respond – growth is slower and pollen may fail to germinate. A 25 percent ozone depletion, for example, would be expected to lower soybean yields by 20-25 percent. It is thought that trees and grasses would be particularly badly affected by higher UV-B levels.

Fish, and the algae on which they feed, may also fare badly. Recent research shows that a 15-day exposure to UV-B levels 20 percent higher than normal can kill off all anchovy larvae down to a water depth of 10 metres. More UV-B is likely to lower fish catches and upset marine ecology. Worldwide, fish currently provide 18 percent of all the animal protein consumed.

Even today's levels of sunlight provide enough UV-B to cause substantial economic damage. It is UV-B that causes paints to fade, window glazing to yellow, and car roofs to become chalky. These kinds of degradation will accelerate if the ozone layer is depleted.

Finally, more UV-B will mean more smog – an effect that will be accentuated if temperatures rise as a result of greenhouse warming. Urban air pollution caused by UV-B could also worsen the problem of acid rain in cities.

In brief

- *if the emission of chlorofluorocarbons were held constant, some 1.65 million cases of non-melanoma skin cancer might be avoided*
- *the costs of adding stabilizers to PVC to counter a 27 percent ozone depletion by the year 2075 would amount to nearly US$ 5 billion*
- *smog levels in Nashville, Philadelphia and Los Angeles could increase by as much as 50 percent if ozone is seriously depleted and temperatures rise*

How UNEP is helping

Concern with the ozone layer was one of the environmental issues that led to the creation of the United Nations Environment Programme in the early 1970s.

UNEP is working with governments, international organizations, and industry to develop a framework within which the international community can make decisions to minimize atmospheric changes and the effects they could have on the Earth. In 1977 UNEP convened a meeting of experts to draft the World Plan of Action on the Ozone Layer. The Plan called for a programme of research on the ozone layer and on what would happen if the layer was damaged. To coordinate this programme UNEP created a special body, the Coordinating Committee on the Ozone Layer (CCOL).

By 1986, the CCOL had met eight times, and had assessed the threat to the ozone layer on several of them – the most recent being in 1986.

UNEP also created the group of experts and government representatives that framed the Convention for the Protection of the Ozone Layer, and is working with governments on a Protocol to the Convention that will require signatories to it to limit their production or emissions of CFCs. This raises difficult commercial issues because CFCs are important industrial chemicals.

> *"A few countries have so far accounted disproportionately for the rise in carbon dioxide but ... the resulting climatic changes will not be allocated according to any earthly idea of justice. No nation acting alone can prevent an increase in atmospheric carbon dioxide."*
>
> **Erik P. Eckholm**
> *Down to Earth, 1982*

UNEP also took action to tackle the greenhouse problem early in the 1970s when the organization joined forces with the World Meteorological Organization (WMO) and the International Council of Scientific Unions (ICSU) to place study of the greenhouse effect on a firm scientific footing.

The results of that initiative have been a much clearer understanding of the nature of the greenhouse effect, and its implications for the future. Thanks to the urgent studies made during the late 1970s and early 1980s, much of the guesswork about both ozone depletion and the greenhouse effect have been removed. The reality of both issues is no longer at issue: the only questions remaining are when, and how much.

Work in coordinating international legal action about the greenhouse effect has so far not been begun except in relation to the CFCs– partly because the issues are more complex and the solutions less obvious. However, UNEP is working with governments, WMO, ICSU and other international bodies to develop a better understanding of the greenhouse effect. This is planned to lead to a framework within which the community of nations will be able to make informed decisions on how best to minimize greenhouse heating and its social effects.

To learn more ...

More detailed accounts of the issues discussed in this publication can be found in:

International Council of Scientific Unions, United Nations Environment Programme and World Meteorological Organization. *Report of the International Conference on the Assessment of the Role of Carbon Dioxide and of other Greenhouse Gases in Climate Variations and Associated Impacts*, Villach, Austria, 9-15 October 1985. Geneva, WMO, 1986.

MacCracken, Michael C., and Luther, Frederick M. (eds.). *The Potential Climatic Effects of Increasing Carbon Dioxide*. Washington DC, US Department of Energy, 1985 (DOE/ER-0237).

Titus, James G. (ed.). *Effects of Changes in Stratospheric Ozone and Global Climate: Volume 1, Overview*. Proceedings of the International Conference on Health and Environmental Effects of Ozone Modification and Climate Change, 16-20 June 1986. Nairobi and Washington DC, United Nations Environment Programme and United States Environmental Protection Agency, 1986.

United Nations Environment Programme. *Possible Effects of Man's Activities on the Ozone Layer and Climate*. Nairobi, UNEP, 1986, UNEP Policy Support Document.

United Nations Environment Programme. *Report of the Eighth Session of the Coordinating Committee on the Ozone Layer*, Nairobi, Kenya, 24-28 February 1986. Nairobi, UNEP, 1986.

Watson, R. T., Geller, M. A., Stolarski, R. S., and Hampson, R. F. *Present State of Knowledge of the Upper Atmosphere: processes that control ozone and other climatically important trace gases*. NASA, Washington D.C., 1986, NASA Reference Publication 1162.

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SUMMARY OF GREENHOUSE EFFECT AND INDUCED CLIMATE CHANGE RESEARCH SURVEY

1. As a basis for identifying research needs relevant to the greenhouse effect and induced climate changes, a review was undertaken of research being carried out within Australia. Questionnaires were sent to all Commonwealth Departments, to State agencies through the Australian Environment Council and the Planning Ministers Conference, to academic, science and technology associations as well as specific tertiary institutions, to all contributors to the Greenhouse 87 Conference and to relevant bodies within the minerals and energy industries.

2. 134 positive responses to the questionnaire were received - 75 from tertiary institutions, 33 from within CSIRO, 7 from within the Bureau of Meteorology, 8 from Commonwealth agencies, 7 from State agencies, 2 from a research centre and 2 from industry. Not all respondents provided full information to the questionnaire.

3. From the survey response current research funding was determined to be $13.8 million - including $9.9 million for atmospheric/climate research, $1.1 million on oceanic research, $1.0 million on primary production studies, $0.85 million on natural resources, and $0.56 million on geological paleo/sedimentary research. Most of the research is being undertaken within the CSIRO, the Bureau of Meteorology and the Universities (combined total of $13.1 million) with considerable logistic and technical support being provided by the Antarctic Division of DASETT in respect of Antarctic and Southern Ocean studies. The amount of resources identified in this way however, is clearly unsuitable as a basis for determining specific research needs since there are wide variations in relevance between individual proposals.

4. Accordingly, proposals were categorised into three groups using the following criteria.

(a) Category A :

(i) Proposals assessing the existence or extent of greenhouse effects and the direct effects of changing concentrations of greenhouse gases on climate and vegetation;

(ii) Time frame of research within 5-10 years.

(b) Category B :

(i) Proposals assessing the potential effects of direct and indirect greenhouse induced climate and other changes in the Australian region and options for preventing or adapting to such effects;

(ii) Time frame of research within 5-10 years.

(c) Category C :

(i) Proposals which, whilst having some relevance, are primarily addressing other issues or being undertaken for other reasons;

(ii) Time frame of research long term, ongoing or uncertain.

5. Of the total $13.8 million being spent on research approximately $4.3 million is spent on category A research, $3.5 million on category B research and $6.0 million on category C research. A summary of the form of research being undertaken in each of the three categories is given below.

Category A ($4.3 million)

6. Proposals relate mainly to climate, atmospheric and oceanic aspects with a relatively minor component studying natural resource and primary production issues.

7. The majority of the research is undertaken within the CSIRO ($3.31 million) - primarily the Institute of Natural Resources and Environment. The Bureau of Meteorology ($0.6 million) - primarily the Bureau of Meteorology Research Centre, and the Universities ($0.37 million) - primarily Melbourne, Flinders, Monash, Macquarie and the University of WA - play a prominent role. The Antarctic Division of DASETT provides logistic and technical support for Antarctic and Southern Ocean research by both agencies and universities.

Category B ($3.5 million)

8. Proposals relate mainly to the assessment of implications for coastal areas, natural resources and primary production and to paleo/sedimentary climate analog studies.

9. Atmospheric/climate proposals comprise mainly monitoring or related model developments necessary for assessing greenhouse scenarios.

10. The main sectors undertaking research within this category are the Universities ($1.4 million) and the CSIRO ($1.3 million).

Category C ($6.0 million)

11. The dominant item within this category, estimated to be $4.63 million, is for ongoing collection and management by the Bureau of Meteorology of the climate data base. This data is collected for a wide range of assessment and management purposes within the Bureau.

12. The bulk of other proposals (numbering 21) were received from Universities and relate mainly to existing natural resource, coastal or primary production studies, which although providing necessary background information for the assessment of greenhouse effects, were established for other purposes.

Other Aspects

13. Only research proposals specifically categorised as relating to the greenhouse effect under the National Energy Research, Development and Demonstration Program (NERDDP) were included in this survey. Consequently there remains a range of energy related projects currently funded by NERDDP which have not been cited in these results.

14. Only a very small amount of socio-economic related research is currently being undertaken in either categories A, B or C.

AUSTRALIA'S RESPONSE STRATEGY TO GREENHOUSE CLIMATE CHANGE

1. It is proposed to:

(a) fund an accelerated program of core research on modelling of regional climate change;

(b) establish a National Greenhouse Advisory Committee to monitor and review greenhouse research;

(c) establish, by 1990/91, a competitive research grants scheme dedicated to greenhouse climate change (particularly impact and response issues);

(d) develop policy and administrative initiatives to address the cause and impacts both within Australia and internationally; and

(e) continue to increase community understanding of the issues involved, especially levels of natural resource use.

Core Research

2. The core research program on the modelling of regional climate change will be accelerated by funds provided to CSIRO, BOM and the Department of Defence (which chairs the Permanent Committee on Tides and Mean Sea Level) by a budget allocation to the Department of the Arts, Sport, the Environment, Tourism and Territories (DASETT).

3. The National Greenhouse Advisory Committee (see below) will receive reports and review progress on the core research program. All research would be reported in scientific literature.

4. An overview of the core research program is at Attachment E. Further details on each of the components are at Attachment F.

5. The program focuses only on the minimum level of work which must be done to enable regional predictions of greenhouse climate change to be made. It does not address the full range of important, related areas such as forests and marine systems (coral reefs etc) which fix carbon dioxide, changes in the oceans and in plant growth arising from impacts in the atmosphere, natural climate variability and climate monitoring (including accurate baseline data). (The wider general climate issues will be addressed in a National Climate Program currently being developed by BOM.)

6. The following funds are sought:

(a) $0.705m in 1988/89 ($0.405m salaries and operational costs, $0.300m one-off capital costs)
(b) $4.832m in 1989/90 ($1.370m one off capital costs)

Ongoing funding will be the subject of a further Cabinet submission later this year (funding of $3.462m pa is anticipated for 1990/91 onwards).

7. A review of the core program and its funding levels will be undertaken in 1991/92.

National Greenhouse Advisory Committee

8. The proposed National Greenhouse Advisory Committee would consist of 4-6 eminent scientists with expertise in climate change and impact issues. CSIRO, BOM and the Academy of Science would be represented. Other members would be experts in fields such as natural ecosystems, agriculture, engineering/town planning etc. The Committee's role would be to:

(a) provide expert scientific advice to Government on greenhouse issues generally and, in particular, advice on priority areas for further greenhouse research (basic science, impacts and responses) and set objectives for a dedicated research grants scheme, with a view to having the scheme operational in 1990/91;
(b) receive reports and review progress on both the core research and, from 1990/91, the grants scheme projects;
(c) provide expert advice to Government on international greenhouse activities;
(d) promote public dissemination of greenhouse information (using where possible existing channels eg. Academy of Science and the Commission for the Future); and
(e) liaise with other relevant organisations to ensure that it does not duplicate efforts elsewhere.

9. Members would be appointed by the Minister for the Arts, Sport, the Environment, Tourism and Territories, in consultation with the Ministers for Administrative Services and Science, Customs and Small Business. The Committee would report to the Minister for the Arts, Sport, the Environment, Tourism and Territories and be serviced by his Department.

10. The Committee would meet quarterly or as necessary, with provision for working groups and review mechanisms. Operating expenses covering travel, accommodation and sitting fees for Committee and working group members, publicity and publishing costs and secretariat support (including establishment, salaries and on cost) are estimated at $0.086m for 1988/89 and $0.634m for 1989/90. An extra 3 ASL are required in 1989/90. (Operating expenses of $0.714m for both 1990/91 and 1991/92 are anticipated with a requirement for an extra 5 ASL from 1990/91 (see paragraph 15 below) for DASETT.)

11. Under the proposed research grants scheme (foreshadowed in paragraph 8 above) project funds would be available from 1990/91 to all researchers, in research institutes, academia and government (including agencies such as the Bureau of Rural Resources, the Australian Biological Resources Study and the Antarctic Division of DASETT). Applications would be subject to peer review (details of the process to be settled in consultation with the Australian Research Council (ARC)).

12. The scheme would complement, but not duplicate, existing arrangements such as the National Energy Research, Development and Demonstration Program.

13. Grants would be awarded by the Minister for the Arts, Sport, the Environment, Tourism and Territories, on recommendation from the National Greenhouse Advisory Committee.

14. Phased introduction of the scheme is proposed to better engender interest and expertise. While funding for the scheme will be the subject of a further submission later this year, funds proposed at this stage are:

(a) $1.500m for 1990/91;
(b) $3.000m from 1991/92 onwards.

15. An extra 2 ASL from 1990/91, plus administrative, support and travel costs, will be required by DASETT to administer both the proposed research grants scheme and the core research program (to be sought in the further submission later this year) under the National Greenhouse Advisory Committee .

Commonwealth Inter-Agency Committee

16. It is proposed that DASETT convene a committee of Commonwealth agencies to co-ordinate Commonwealth action on greenhouse issues generally. Key agencies on the committee would include the Departments of Primary Industries and Energy, Industry, Technology and Commerce/CSIRO, Administrative Services/BOM, Community Services and Health, Immigration, Local Government and Ethnic Affairs, Transport and Communications, Employment, Education and Training, Defence, Foreign Affairs and Trade, Attorney-General's and the Prime Minister and Cabinet/ASTEC.

17. This committee would assume responsibility for co-ordinating Australia's input into the WMO/UNEP Intergovernmental Panel on Climate Change (IPCC) currently undertaken by a co-ordinating committee convened by ASTEC.

Australian Participation in International Developments

WMO-UNEP Intergovernmental Panel on Climate Change (IPCC)

18. The panel is currently reviewing available scientific material and assessing likely impacts and possible response strategies and has planned a heavy work program for this and the next few years.

19. The WMO-UNEP IPCC is the principal forum for the development of an international policy response to climate change issues.

20. To date, Australia has made an effective and positive contribution to the work of the Panel. This must continue if our interests are to be protected. Japan, USA, UK, Denmark, Finland, Canada and Switzerland have already pledged financial support. Australia has also been requested to provide financial support.

21. Funding of $10,000 is sought in 1988/89 for an Australian contribution to the running of the Panel. $80,000 is sought in 1989/90 for a contribution to the Panel ($10,000) and associated workshops ($50,000) and necessary travel within Australia and administrative support for the development of soundly based Australian positions. (A reduced amount of $50,000 is anticipated for 1990/91 due to the fewer number of workshops to be held in that year). Funding for Australian representatives to attend Panel and Working Group meetings has been included separately under DASETT co-ordination funds.

UNEP Climate Impact Studies Programme

22. A contribution of $50,000 per annum is proposed for the UNEP Climate Impact Studies Programme. This Study is one of four subprograms under the World Climate Program and the funds sought will be used to stimulate impact assessment work within the Australian/Asian/South Pacific region.

International Geosphere-Biosphere Program

23. The International Geosphere-Biosphere Program will be the preeminent international scientific program of the 1990's and, amongst other things, will further our understanding of the role of biosphere-climate interactions and possible impacts and responses of the biosphere to predicted climate changes.

24. Funding is sought to assist the Australian Coordinating Committee, established under the auspices of the Australian Academy of Science, develop an Australian participative research program for the IGBP: $40,000 in 1988/89 and $150,000 in 1989/90 (with an anticipated requirement of $150,000 in 1990/91).

Other International Initiatives

25. Greenhouse related climate change is currently being addressed in a wide range of international fora. Heads of Government met in the Netherlands on 11 March 1989. Ministerial meetings will be held in Japan (September 1989) and the Netherlands (November 1989).

26. Climate and climate change has been included as a project in the United Nations system-wide medium-term environment program for the period 1990-1995. Greenhouse climate change is a feature of UNESCO's Climate Change and the Oceans program.

27. Initiatives are also being undertaken within the OECD Environment Committee (which are being closely co-ordinated with the International Energy Agency and the Nuclear Energy Agency), and the South Pacific Regional Environment Program. Conferences are being held to develop a possible Law of the Atmosphere convention.

28. Funding is sought under DASETT co-ordination to enable Australia to actively participate in the developing

international activities (both research and policy):

(i) $0.081m in 1988/89 and $0.252m in 1989/90, (with anticipated requirements of $0.224m in 1990/91 and $0.182m in 1991/92) to enable appropriate Australian experts from research organisations, academia and government agencies to attend relevant international conferences to actively promote Australia's interests;

(ii) $0.075m per annum for the secondment of an officer from DASETT to UNESCO for two years (1989/90 and 1990/91) to work on the Climate Change and the Ocean program (this will provide a strong southern hemisphere emphasis); and

(iii) $0.400m over 1989/90 and 1990/91, ($0.100m in 1989/90 and $0.300m in 1990/91) to enable Australia to host a major international conference within Australia in 1990/91 on the greenhouse effect and related climate change issues, as foreshadowed by the Prime Minister in Parliament in November 1988. The major purpose of the conference will be to focus on policy issues of particular importance to the region and the southern hemisphere as a means of countering the predominant northern hemisphere bias that currently dominates international discussion on this issue. It is proposed that representatives be invited (and where necessary financially supported) from Africa, South America, Asia and the South Pacific in an effort to make the conference representative of the southern hemisphere.

DASETT Activities

29. An additional 7 staff are required within DASETT to supplement existing resources for a range of policy development tasks including the development of position papers, reviewing overseas initiatives, servicing international commitments, data and information collection and dissemination, the development of an education program, incorporating greenhouse climate change considerations into environmental impact assessment procedures, and associated corporate services support. Major tasks in the short term relate to holding a regional workshop in 1989/90 to concentrate on impacts and to hosting a major international conference in Australia in 1990/91 to focus on regional and southern hemisphere issues (see above). Additional administrative and support funds for these activities are required in addition to the staff and funds set out earlier in this attachment to service the Greenhouse Committee and, from 1990/91, administer the grant scheme for research funding. Establishment, salary, on costs and domestic travel for these additional staff are estimated at $0.067m in 88/89 and $0.479m in 89/90. (Funding from 1990/91 will be the subject of a further submission with anticipated requirements of $0.407m in 90/91 and $0.407m in 91/92.)

FINANCIAL BREAKDOWN

30. The following funds are sought:

	88/89 $m	89/90 $m	90/91* $m	91/92* $m
Core research	0.705	4.832	3.462	3.462
Grants scheme	-----	-----	1.500	3.000
Greenhouse C'ttee	0.086	0.634	0.714	0.714
WMO-UNEP IPCC	0.010	0.080	0.050	-----
UNEP climate impact studies	0.050	0.050	0.050	0.050
IGBP planning	0.040	0.150	0.150	-----
DASETT activities/ coordination	0.148	1.006	1.006	0.589
TOTALS	1.039	6.752	6.932	7.815

Note: * Proposed; approval for 1990/91 and 1991/92 funds is to be sought in a further submission later this year from the Minister for the Arts, Sport, the Environment, Tourism and Territories reporting back to Cabinet on greenhouse issues.

Australian Climate Change Core Research Program

CLIMATE AND CLIMATE CHANGE

Climate equilibrium on earth is maintained by the solar-terrestrial radiation balance. Climate itself is the result of the complex interaction of the earth/atmosphere/ocean/biosphere system. Atmospheric scientists around the world have used their understanding of this system to construct computer models which allow the description of how the atmosphere varies from time to time and place to place (weather forecasting). Using such models to describe average situations allows the simulation of climate.

It is now well-established that the composition of the earth's atmosphere is changing and that the increasing levels of trace gases in the atmosphere are likely to upset the solar-terrestrial radiation balance. To use computer models as a tool to determine how the earth's climate will respond, with the aim of placing specific emphasis on how Australia as a whole and from region to region will be affected is the essence of the proposed climate change program.

TIMING/URGENCY

While it has been long recognized that atmospheric changes and the build-up of radiatively active gases in the atmosphere could in principle lead to a global warming, only in recent years have scientists collected enough evidence to estimate how and why these gases are increasing. This evidence of changing atmospheric composition, the speed of this change, the link with human activities and the combined effect of the various atmospheric trace gases has brought about the realization that significant climatic change can be expected over the next few decades.

More than anything else, the fact that the changes will occur at rates faster than experienced at any time during human or geological history dictates the urgency associated with obtaining the best possible estimates of how climate is expected to respond. In particular, there is a great need to determine what the changes for Australia will be, and how they will affect specific regions. Finally, there is another reason for urgency: it is to know what the changes will be and what impact they are likely to have so that these considerations can be used in decision making on what mitigation strategies might be devised and how effective they are likely to be. In order for decisions to be made on energy use, for example, the impact of the changes and the associated economic and social costs will have to be well-defined.

CURRENT RESEARCH

In terms of carrying out the core research which will lead to estimates of how climate over Australia is going to change, two organisations have the necessary experience and expertise.

They are the CSIRO and the Australian Bureau of Meteorology. Research projects addressing the issue of changing atmospheric composition, climate and climate change are already in place. However, to make significant scientific progress on a time-scale matching the new sense of urgency for better estimates of regional climate change, a significant infusion of resources is needed.

THE ENHANCED RESEARCH EFFORT

The attached project propoals detail the additional resources needed, and the specific purpose to which they will be put.

Project A1 describes the collaborative effort between CSIRO and BoM to develop Australian Climate Models to the point where they can be used for regional climate studies. It has to be emphasised that this is a crucial research project of immense complexity. Hence it will have to be seen as a long-term commitment. Paired with A1 is project A2 which will use the results from A1, as well as results from other approaches to the problem of climate change to provide methods and mechanisms for estimates of regional climate change to be made available while the core research progresses.

There is a second avenue of core research which needs to be pursued in parallel with the above. These projects will serve to provide better descriptions of the earth/atmosphere/ocean system to be used in the climate modelling studies. They are: Projects B1 and B2, detailed measurements of current and post greenhouse gas concentrations which are needed to estimate future changes; Projects C1, C2 and C3 investigating the trace gas and heat fluxes over the oceans and the role of the ocean in climate change; and Projects D1-D4 which are all concerned with the response of terrestrial biosphere system to the changing climate and changing carbon dioxide concentrations, and how these changes will in turn influence atmospheric processes. All the abovementioned research projects are essential for any impact studies to be applied successfully.

It has to be stressed that the new funds and staff requested will be used to complement a research effort which covers some 30 CSIRO and 7 BoM research staff and an estimated current expenditure of $3,000,000 (CSIRO) and $560,000 (BoM).

Finally, there is a third avenue of core funding which needs to be addressed. This is concerned with sea-level change. Future changes in global sea level will depend on the response by the oceans and land-based ice to the climat ic changes. However, in order to apply any estimates of global and regional sea-level change there has to be an accurate record of the current natural fluctuations and trends in sea level on a regional scale. Project C4 describes the plan to establish 8 state of the art sea-level monitoring stations at appropriate sites around Australia. The proposal is sponsored by the Permanent Committee on Tides and Mean Sea Level.

Attachment E.

CABINET-IN-CONFIDENCE

CSIRO Institute of Natural Resources and Environment
Climate Change Proposals
(Core research)

	Institution †	Funding(k$) Recur.	One-off	Notes
A. Climate Change Modelling and Prediction				
1a. General circulation modelling of regional climate change for the Australian region	DAR	640		Part of August 88 DASETT proposal
1b. General circulation modelling of regional climate change for Australia	BMRC	556		
2. Detailed estimates of regional climate change selected parts of Australia	DAR	320		July 88 AEC proposal
3. Modelling oceanic processes relevant to climatic change and prediction	DAR/DO	290		
B. Atmospheric Greenhouse Gases				
1. [illegible]asurement programs relevant to the validation of climate change models. 1.Upgrading atmospheric greenhouse gasmeasurements	DAR	80	210	
2. Measurement programs relevant to the validation of climate change models. 2.Historical records of greenhouse g[illegible] concentration from Antarctic ice-core analysis	DAR/AAD	85	20	
C. Atmosphere/Oceans Interaction				
1. The role of the southern hemisphere oceans in taking up carbon dioxide: physics, chemistry and ocean productivity	DAR/ DO/DF	200	260	
2. Measuring thermal structure and sea level for climate studies	DO	170	70	
3. The role of the Southern and South Pacific Oceans in climate change	DO/AAD	300		Phased develop.
4. Baseline sea level monitoring stations and a national sea [illegible]l facility	PCTMSL	186	800	Phased develop.
D. Atmosphere/Terrestrial Biosphere Interactions				
1. Biospheric inputs to atmospheric general circulation [illegible] climate prediction models	DAR/CEM/ DWE/DWR	170	60	Phased develop.
2. Climate change and water use efficiency	CEM/DPI/ANU	120	100	
3. Satellite monitoring of Australian region climate change	DAR/DWE	175	150	
4. Implications of climate change for ground water recharge, rainfall and temperature	DWR	170		
Totals (k$)		3462	1670	

† AAD, Australian Antarctic Division; BMRC, Bureau of Meteorology Research Centre; CEM, CSIRO Centre for Environmental Mechanics; DAR, CSIRO Division of Atmospheric Research; DO, CSIRO Division of Oceanography; DPI, CSIRO Division of Plant Industry; DWE, CSIRO Division of Wildlife & Ecology; DWR, CSIRO Division of Water Resources; PCTMSL, Permanent Committee on Tides and Mean Sea Level.

CABINET-IN-CONFIDENCE

Climate Change CORE RESEARCH PROGRAM - Details

A.1a General Circulation Modelling of Regional Climate Change for Australia

CSIRO Division of Atmospheric Research

Background

This is the key core research program for climate research as it aims to provide the most powerful technique to synthesise all atmospheric, terrestrial and atmosphere/ocean processes at work and to simulate climate and climate change. Current capacity to simulate regional climate change is extremely limited. The task of improving both the basic understanding and the incorportaion of this understanding into regional climate prediction models is enormous but the implications to the Australian community demand that this work proceed without delay.

Rationale

Climate is simulated by means of general circulation models of the atmosphere to which eventually an ocean model will be attached. Experiments will be carried out simulating present and future climate by using 'normal' and 'double' CO_2 concentrations in the model atmosphere. In order to provide a more detailed assessment for the Australian region, the capability will be developed to 'nest' a higher resolution climate model specific to the Australian region within the global general circulation model. Improved representations of all relevant processes will be included as core research in other areas provides better ways of parameterising them.

Objective

To provide increasingly reliable estimates of southern hemisphere and regional climate change resulting from observed and expected future increases in trace gases and (possibly) changes in land utilisation.

Description

Because of the relative stages of development and computing requirements of different models, a 4-level model will be used to provide the first greenhouse estimates for Australia. Multiannual simulations of at least ten years will be carried out, with the emphasis on assessing potential changes at the regional level and daily extremes in rainfall, temperature, etc. A 9-level model developed at the (now defunct) Australian Numerical Meteorological Research Centre, is being further developed as a climate model with a nested high resolution area over Australia. With this nested capability it will be able to simulate more local climatic changes and provide much of the detail necessary for commercial and political decision making.

It is proposed to couple both models to oceanic models as this is an absolutely critical requirement for simulating the climatic system adequately. Preliminary coupling experiments are underway with the 4-level model but more advanced oceanic models will need to be developed.

The models will be capable of incorporating improvements in understanding the relevant physical processes as these improvements arise.

Close cooperation with scientists in the Bureau of Meteorology Research Centre will be maintained during this development and the running of the models.

Staffing

Current staff of 3 Research Scientists and 4 support staff will be increased by 4 Research Scientists and 4 Experimental Scientists.

Budget*

Salaries and on-costs (4 RS, 4 ES)	$440,000/year
Operating	$200,000/year
Total:	$640,000/year

* Additional to these figures will be the cost of the models on a mainframe computer (i.e. the CYBER 205, currently free of charge, and the access to CSIRONET network and storage facilities at reduced rates). This research is very dependent on CSIRONET-type services - hence the cost will be sensitive to charging rates.

Contacts: G.B. Tucker; G.I. Pearman, J.S. Frederiksen, B.G. Hunt.

A.1b General Circulation Modelling of Regional Climate Change for Australia

Bureau of Meteorology Research Centre

Background

This attachment describes the Bureau of Meteorology Research Centre's component of the joint CSIRO-Bureau of Meteorology climate modelling core research program in support of climate change assessments in the Australian region.

A global prediction and climate model is currently used by the Bureau of Meteorology Research Centre (BMRC) for global medium range prediction and global climate simulation over a range of model resolutions. The model, originally developed in the (now defunct) Australian Numerical Meteorology Research Centre (ANMRC) under the joint sponsorship of the Bureau of Meteorology and the CSIRO, has been substantially extended in the last 3 years in the BMRC and now constitutes a state of the art global modelling facility. In more recent times the model has also been substantially vectorised and is now fully compatible with the Bureau's recently commissioned ETA 10 supercomputer.

Objective

To develop the Bureau of Meteorology Research Centre Global Climate Model to enable the investigation of the impact of increased greenhouse gases on the climate of the Australian region.

Description

The problem of developing more reliable regional predictions of climate change involves the systematic study of the various shortcomings of the model and the development of improvements to overcome these. Many of the improvements required for the climate change simulations are presently being studied in the BMRC where the model is used primarily for medium range predictions.

Five additional staff are required in order to fulfil the BMRC objectives of the modelling project. The additional staff are needed

(i) to develop the model capabilities
(ii) to develop diagnostic software to analyse the model output
(iii) to maintain the model code
(iv) to analyse the model output and
(v) to liaise with CSIRO and other groups working on the project

Staffing

The project will require in BMRC four additional science staff and one additional CSO. The functions of each additional staff member are: Coordination of model development (Science); Climate model development (Science); Ocean model development (Science); Modelling of climate variability (Science); and Model Maintenance (CSO).

Budget

Salaries and on-costs	$352,000 per year
Operating costs	$204,000 per year
Total:	$556,000 per year

Contact: M.J. Manton

A.2

Detailed Estimates of Regional Climate Change for Selected Parts of Australia

CSIRO Division of Atmospheric Research

Background

This is the key applied research program running in parallel with the general circulation modelling activity. In addition to the specific use of results obtained from the general circulation modelling of climate change, a variety of techniques will be used to develop a methodology to assess regional climate change.

Rationale

While the core research effort in the modelling of climate change is being advanced over the next 5-10 years, there will be an urgent need for the best estimates of regional climate change to be provided at specific intervals. These estimates will be based on the latest modelling results, both from the Australian modelling studies and, where appropriate, Northern hemisphere studies that are relevant to Australia. These are to be supplemented by a variety of other techniques which will include analyses of past and current climate data, and studies of synoptic data to find associations with climate variables that are more difficult to predict explicitly.

Objective

To provide the best available specific and regional estimates of details of the climate change likely to be experienced in critical areas of Australia.

Description

Through this applied research project we will obtain the best available estimates of regional climate change. Methodologies will be developed to obtain composite regional estimates using:

- results from high resolution models and low resolution models of atmosphere and atmosphere and ocean,
- comparisons with modelling results from other (northern hemisphere) centers,
- inferences from palcoclimatic changes,
- results from data studies relating climate elements that are not predicted (or well predicted) by models to those that are adequately handled.

This program would be the main interface with State authorities and the Australian Environment Council sponsored "greenhouse" activities. Where appropriate, scientists will collaborate with others in other CSIRO Divisions, in the Bureau of Meteorology Research Centre, the National Climate Centre and the Australian Antarctic Division as well as State instrumentalities.

Staffing

Current staff of 1 Research Scientist and 1 support staff will be increased by 2 Research Scientists and 2 Support Staff. This combined group would provide the base effort which would be supplemented by regional specialists paid for by State funding.

Budget*

Salary and on-costs (2 RS, 2 ES)	$220,000/year
Operating	$100,000/year
Total:	$320,000/year

* Additional to these figures will be the cost of running the analyses on a mainframe computer (i.e. the CYBER 205, currently free of charge, and the access to CSIRONET network and storage facilities at reduced rates). This research is very dependent on CSIRONET-type services - hence the cost will be very sensitive to charging rates.

Contacts: G.B. Tucker, G.I. Pearman, A.B. Pittock.

A.3 Modelling Oceanic Processes Relevant to Climatic Change and Prediction

CSIRO Division of Atmospheric Research & Division of Oceanography

Background

Climatic prediction of global change associated with greenhouse gases and other perturbers can only be undertaken realistically with large scale numerical models. Such predictions require coupled atmospheric-oceanic models, while evaluation of oceanic mechanisms per se require a range of oceanic models. Atmospheric modelling is very advanced in Australia but oceanic modelling is fragmented and limited, and no adequate oceanic global model exists within Australia. A major commitment is needed to rectify this critical gap in our climatic research.

Rationale

A coupled model will result in increasingly realistic simulations of climatic events by DAR, while access to the oceanic model will permit DO to optimise their studies of oceanic processes and mechanisms. The latter will in turn materially improve the coupled model.

Specific objective

To develop a primitive equation model of the global oceanic circulation for coupling with existing atmospheric models for climatic studies, and to use this oceanic model in investigations of oceanic processes.

Description of project

The fastest developmental path would be to obtain copies of overseas global oceanic models and to evaluate them for our use. It is proposed that 3 such models should be assessed in this way. One model would be selected and used by both DO and DAR subsequently. The immediate DAR application would be to incorporate the oceanic model into a coupled model and to use it in greenhouse and drought studies. DO would use the oceanic model in a "stand alone" mode, and would apply it to interpret their ongoing observational studies. Both Divisions would use their models in investigations appropriate to the international projects WOCE and TOGA. Specific studies would embrace such phenomena as sea surface temperature anomalies associated with El Nino events, boundary currents etc. The close collaboration between the two Divisions will ensure that new mechanisms and interpretations arising from field studies by DO are efficiently incorporated into the coupled model.

Timetable

The first 6 months would be used to evaluate the imported oceanic models and to choose one for subsequent use. The following 6 months would see the model being set-up for experimental use. Subsequently coupled model experiments and oceanic experiments per se would be conducted. Given the nature of current climatic problems no upper timeframe can be set to this research.

Staffing

Two new research scientists and two programmers would be required. One RS and 1 programmer at DAR, 1 RS and 1 programmer at DO. For the initial 6 months model evaluation period all staff would be located at DAR. Existing DAR staff will provide the atmospheric component of the coupled model, and the interfacial exchange mechanisms. Existing staff at DO will provide modelling support, develop parameterization of oceanic mechanisms and observational inputs.

Special needs

Access to a supercomputer and a stable research environment. Frequent exchange of staff between DO and DAR to maximise the mutual benefits of the expertise of the individual Divisions.

Budget*

Salaries and on-costs (2 RS and 2 programmers)	$220,000	per year
Operating	$70,000	per year
Total	$290,000	per year plus computing

* Additional to these figures will be the cost of the models on a mainframe computer (i.e. the CYBER 205, currently free of charge, and the access to CSIRONET network and storage facilities at reduced rates). This research is very dependent on CSIRONET-type services - hence the cost will be sensitive to charging rates.

Contacts: B.G. Hunt, J.S. Godfrey

B.1 Measurement Programs Relevant to the Validation of Climate Change Models: 1. Upgrading Atmospheric Greenhouse Gas Measurements

CSIRO Division of Atmospheric Research

Background

The DAR maintains programs which measure the major atmospheric gases implicated in Greenhouse warming and Ozone destruction. The programs are providing unique information in several important aspects, including geographical access to poorly studied but critical southern ocean regions. Several years of funding constraints have created a situation of dated and deteriorating equipment inadequate for modern measurement requirements.

Rationale

While contemporary global budgets have been established for many trace gases, these are still crude. The prediction of future trace gas concentrations on the basis of current budgets becomes more uncertain looking ahead several decades. There is an urgent need to evolve predictive models so that serve as early warning of equilibria readjustments or positive feedbacks. The improvement of current models is data limited.

Objectives

(i) Restore existing sampling methods and improve sampling frequencies.
(ii) Greatly reduce manpower requirements by automation of repetitive manual tasks
(iii) Improve measurement precision to stage-of-art
(iv) Interactively apply the improved tools to predictive trace gas budgeting

Description

(i) Construct replacement pump units and/or refurbish existing units; (ii) Construct new flask box units to replace breakages and improve sampling frequency at key sites; (iii) Upgrade halocarbon analyses to include important minor species (F113, CH_3CCl_3, CCl_4) ; (iv)Automate halocarbon and CARLE (CO_2, CO, CH_4) gas chromatography for multiple flask operation; (v) Automate CO_2 extraction process for isotope analyses; (vi) Convert CO_2 storage vessels to reduce fractionation effects; (vii) Replace mass spectrometer inlet system and control or replace mass spectrometer; (viii) Markedly improve vertical sampling throughout the troposphere

Timetable

The new pump units and flasks can be built from existing design in six months. Acquisition of a GC and automation of the GC's plus testing will take about 1 year, as will acquisition of new mass spectrometer facilities. With staffing assistance most of these can run concurrently. With improved sampling and upgraded analyses, an intensive observation period of 3-5 years (at least 1 El Nino "cycle") is envisaged prior to contraction to much fewer strategic sampling sites.

Staffing

An ES for 3 years to assist with network upgrade and subsequent data management upgrade. 1/2 TA for 3-5 years for flask management and analysis.

Special Needs

The mass spectrometer upgrade ensures the continuation of a unique aspect of the current program, which is providing the only global information on ^{18}O in CO_2. A fully upgraded facility has much wider application in permitting small sample analysis on eg ice core CO_2 and atmospheric CH_4, both recognised as important sources of new information on these species.

Budget

Equipment:	Flask program upgrade	$30,000	
	Automation	$30,000	
	New GC and NDIR	$50,000	
	Mass spectrometer (upgrade to 1975 level)	$100,000	
	Subtotal	$210,000	
Salary and on-costs (1 ES, 1/2 TA)		$60,000	per year
Operating		$20,000	per year
Total		$80,000	per year plus $210,000 (one-off)

Contacts: R.J. Francey, P.J. Fraser

B.2 Measurement Programs Relevant to the Validation of Climate-Change Models
2. Historical Records of Greenhouse Gas Concentration From Antarctic Ice-Core Analysis

CSIRO Division of Atmospheric Research and Australian Antarctic Division

Background

Key factors in the understanding of the bio-geochemical cycles of greenhouse gases are the concentrations and sources of these gases in pre-industrial times. Through the Australian Antarctic Division's ice-core drilling program CSIRO scientists have access to samples of air trapped in Antarctic ice over the past 400 years or more. Already these have provided excellent data of the pre-industrial atmosphere levels of CO_2 and CH_4. This in turn has assisted in understanding the natural variability of Greenhouse gases, to what degree they have been influenced since industrialization and why. The Australian ice material is second to none in its quality and suitability for such studies, and CSIRO and the Antarctic Divison have pioneered techniques for the extraction and measurement of such ancient gas samples. Sever funding restrictions in recent times have brought this research to a halt.

Rationale

High precision measurements of greenhouse gases in the global atmosphere have been carried out over the last decade. An accurate determination of the concentrations of the gases in the past is invaluable to the understanding of their budgets, and will assist in the evaluation of their contribution to the greenhouse warming. Proven extraction and measurement techniques for air trapped in Antarctic ice have been developed in recent years. This proposal is for the application of these techniques to greenhouse gas studies.

Objective

Establish the biogeochemical cycles of the major greenhouse gases so as to understand the causes of increases and develop reliable predictive capability.

Description

Utilize the new ice-core air analysis techniques for the measurement of the isotopic composition and concentrations of greenhouse gases (CO_2, N_2O, CH_4) and other gases related to the ozone depletion issue (CFCs, CCl_4). Attempts will be made to get the history of ozone and selected hydrocarbons to build a clear understanding of the chemical state of the atmosphere and how this has evolved during industrialization.

Staffing

DAR scientists involved in this project would be I.E. Galbally, R.J. Francey, P.J. Fraser and G.I. Pearman. These scientists provide complementary background to the major greenhouse-gas issues, while a new RS is required to take prime carriage of the ice-core program. Antarctic Division staff involved would be V.I. Morgan, D.M. Etheridge and T.M. Jacka.

Budget

Salary and on-cost (1 RS)	$60,000	per year
Equipment costs (one off)	$20,000	
Operating costs	$25,000	per year
Total	$85,000	per year plus $20,000 (one off)

Contact: G.I. Pearman

C.1 The Role of Southern Hemisphere Oceans in Taking up Carbon Dioxide: Physics, Chemistry and Ocean Productivity.

CSIRO Division of Atmospheric Research, Division of Oceanography & Division of Fisheries

Background

Primary productivity in the surface waters of the oceans scavenges carbon dioxide (CO_2) from the air and incorporates it into plant material that is grazed and sinks into the ocean depths. In this way the sediments are a principal mechanism for the removal of atmospheric CO_2 and hence play a vital role in determining the rate at which fossil fuel CO_2 accumulates in the atmosphere and the development of the Greenhouse Effect.

Rationale

Studies at CSIRO suggest that major global sinks of atmospheric CO_2 occur in the region of the Subtropical Convergence to the south of Australia and in the Antarctic Convergence in the Southern Ocean. The actual mechanisms involved are not understood so that existing models of the global carbon cycle are not mechanistic and therefore incapable of accounting for the possible effects that Greenhouse-induced climate change might have on the effectiveness of this sink in the future.

Specific Objective

To describe the interaction of biological and physical processes in the determination of the oceanic sink strength for atmospheric CO_2 in the oceans to the south of Australia and establish the methodologies for the ongoing monitoring of salient features of the region.

Description of Project

The work will integrate oceanic CO_2 measurements with the use of satellite imagery to determine the spatial and temporal extent of the major sinks of CO_2 in the Australia region. Equipment deployed on Australian research vessels ("Franklin" and "Southern Surveyor", as well as Antarctic Division vessels "Icebird" and "Aurora Australis") will allow the measurement of pCO_2 levels in Australasian waters. The data from ship sampling will be compared with that from the Coastal Zone Color Scanner (CZCS) on the NIMBUS-7 spacecraft.

These techniques will allow the first high resolution look at the productivity and global significance of the waters of the Australasian region, and establish techniques for the extrapolation of estimates from the small to the regional and zonal space scales. The latter is a fundamental problem in several fields of global environmental science.

Timetable

First year: build and implement underway sampling system. Set up CZCS data base. Years two to five: collect CO_2 data from ships at sea, analyse CZCS data base, commence the modelling effort. Beyond year three: receive SeaWIFS data data (1991 launch) and begin studies on the interannual variability of atmospheric CO_2, oceanic pCO_2 and productivity.

Staffing

The following will be required: DO: One RS and assistant to set up and analyse underway sampling data. DF: Two technicians to analyse satellite data and produce routine data products.

Budget

Initial: three underway systems @ $80,000	$240,000	
laser disk archive system	$20,000	(total initial = $260,000)
Ongoing: salary and oncosts RS plus TO (DO)	$90,000	per year
two technicians (DF)	$70,000	per year
annual maintenance	$40,000	per year (includes research vessel charges)
Total	$200,000	per year + $260,000 (one-off)

Contacts: G.P. Harris, G.I. Pearman, D. Mackey

C.2 Measuring Thermal Structure and Sea Level for Climate Studies

CSIRO Division of Oceanography

Background

Ocean models are an essential component of modern methods of predicting climate change, due to the Greenhouse Effect or other causes. Ocean data are needed to document changes in the ocean, and to verify the models. This proposal aims to provide time series of data over several years, in the broad ocean areas around Australia. It will extend the present DO studies of the El Nino Southern Oscillation (ENSO) phenomenon to higher latitudes where the Greenhouse warming is expected to be greater.

Rationale

Special techniques are required to obtain long-term, large-area ocean observations. Our experience in ENSO studies suggests that the most cost- effective method combines data from a mix of merchant ship observations, island tide gauges, satellite data, drifting buoys and moorings.

Objectives

To obtain a decade-long time series of ocean data around Australia, (i) to document changes in sea level and thermal structure, and (ii) to verify models which predict the changes. Most importantly, sea surface temperature needs to be modelled in order to predict climate.

Description of Project

The first type of observation uses expendable probes (XBTs) dropped from merchant ships under way, that measure temperature profiles in the top 700 metres. They are now routinely used on six transequatorial shipping routes north of Australia. It is proposed to strengthen this network and extend it to higher-latitude routes. Second, tide gauges are maintained at ten island sites around Australia; it is proposed to extend and strengthen this network. Third, to extend data coverage to regions that are not covered by merchant ships or islands, satellite measurements of sea level and SST will be obtained from NASA and calibrated. Finally, the western equatorial Pacific is a region of great importance for global climate, and usual (extra-equatorial) measurement methods break down. Current meter moorings are proposed north of Papua New Guinea. The data will be compared to results from ocean models, driven by observed winds and heat fluxes.

Timetable

To verify models of climate change, a data set covering about ten years is needed so that a variety of year-to-year variations are sampled as well as mean seasonal conditions. Experience with our study of ENSO suggests that the first meaningful comparisons of observations and models will occur after about five years.

Staffing

Present staff are as follows:

XBT work: Dr Meyers + 2.5 sea level work: Dr Godfrey + 1.5 equatorial mooring work:
Dr Lindstrom + 1 satellite altimeter work: Dr Church

One additional Experimental Scientist is needed for XBT, sea level and mooring work.

Special Needs

The data must be collected regularly, without major gaps; there is therefore a need for assured funding, over the proposed ten-year time scale of the project. At present, our ENSO study (costing $320,000/year) is maintained by an insecure mix of funds from a variety of sources. Our budget below assumes that funding from Australian Research Council (one sixth of the total) will not be available due to restrictions on applications from CSIRO. It also assumes that all the XBT deck units, sea level gauges and current meters used in the ENSO study will have to be replaced.

Budget

Salaries for one additional staff	$40,000	per year
XBTs	$90,000	per year
Instruments	$70,000	
Maintenance	$40,000	per year
Total	$170,000	per year + $70,000 (one off)

Contact: G. Meyers

C.3 The Role of the Southern and South Pacific Oceans in Climate Change

CSIRO Division of Oceanography & Australian Antarctic Division

Background

Climate change due to the Greenhouse Effect in the southern hemisphere is expected to be different to that in the northern hemisphere because the southern oceans are so large. This discovery, which was made with idealised ocean/atmosphere models, highlights the importance of the southern hemisphere oceans to the world climate. Models used to predict climate change will have to include oceanic processes such as the poleward transport of heat by the oceans, the Antarctic Circumpolar Current and the formation of water masses that carry heat from the surface layer into the ocean interior.

Rationale

In the South Pacific, a dearth of appropriate observations has prevented accurate estimates of the magnitude of the poleward heat transported by the ocean, and of estimates of its seasonal and interannual variability. A key to determining the magnitude of this heat flux is understanding the transport of the East Australian Current. Water masses that carry heat and gases away from the surface layer and into the ocean interior are formed near the Antarctic Circumpolar Current. Recent model results illustrate the importance of the Antarctic Circumpolar Current for climate prediction. Its transport is best estimated where the zonal flow is constrained by boundaries; e.g. south of Tasmania.

Objectives

To determine (1) the transport of the East Australian Current, and hence the poleward transport of heat in the South Pacific, (2) the transport of the Antarctic Circumpolar Current south of Tasmania, and (3) the rates at which water masses form in the Southern Ocean. These objectives can be realistically achieved now because of the development of new technology and the existence of the World Ocean Circulation Experiment (WOCE) which will provide much supporting data.

Description of project

To determine the transport of the East Australian Current, we plan a series of hydrographic sections in the western South Pacific Ocean, using modern oceanographic equipment aboard CSIRO's oceanographic research vessel "Franklin". To interpret the shipboard observations adequately, it will be necessary to collect data with moored current-meters, satellite-tracked drifters, and satellite altimeters (which measure sea-surface height). Detailed observations are required for a minimum period of two years followed by a longer period of monitoring. To estimate the poleward heat fluxes, these observations will be combined with transPacific sections that will be completed for WOCE. To determine the transport of the Antarctic Circumpolar Current, an annual section between Tasmania and Antarctica is proposed with Antarctic Division logistic support. Over the long-term, the transport would be measured using pressure gauges, which we plan to deploy in collaboration with investigators from the United States. These sections, and process-oriented studies, will be used to estimate local rates of formation of the central waters of the main thermocline.

Timetable

A start on this project will be made in 1989 with two cruises of RV Franklin. The main phase of the South Pacific work would begin with the launching of the TOPEX/POSEIDON satellite in 1992. The Southern Ocean section would begin soon after the delivery of the new Antarctic vessel and would be continued for five years.

Staffing and Budget

The magnitude of the work required to be completed and the necessity to use satellite altimeter data (a new initiative for CSIRO) will require one additional research scientist and one assistant. Average annual costs are:

Salary and on-costs (1 RS, 1 TA)	$85,000		
Satellite-tracked drifters	$70,000		
Mooring equipment and maintenance	$40,000		
Sea-going expenses	$80,000		
Computing costs	$25,000		
Total:	$300,000	per year	(phasing in of this program is necessary)

Contacts: J.A. Church, G.R. Cresswell, E.J.Lindstrom

C.4 Baseline sea level monitoring stations and a national sea level facility

(Permanent Committee on Tides and Mean Sea Level)

Background

Sea level monitoring has a major role to play in understanding the total ocean atmosphere environment. If measurement sites are properly selected the measured levels can be more representative of the regional oceanography than other more variable parameters, such as coastal temperature and salinity. The technology required for a long-term monitoring program is very modest when compared with the cost of other monitoring systems.

Rationale

Sea level changes encompass a diverse set of processes. To resolve changes due to individual factors, particularly those on long time scales, like those through thermal expansion of the ocean due to the greenhouse effect, long and continuous data records are required where a high degree of datum stability is maintained. In addition it is necessary to establish a means of determining absolute sea level change by distinguishing sea level variations from land subsidence.

Objective

To establish 7 - 8 state of the art 'super' monitoring stations at appropriate sites around the country to serve as baseline stations for the existing monitoring network and provide high accuracy sea level and geodetic reference sites.

Description

Instrumentation requirements are essentially designed for ease of maintenance and data collection and to provide system duplication to cover the whole frequency range and to provide backup. The proposal would be for a pressure sensor, vented to the atmosphere, or similar system to cover the high frequency signal and a traditional float stilling well sensor to cover the low frequency signal. Data will be digitally logged, both electronically (either solid state memory or magnetic tape) and mechanically (using punched paper tape). The data will be telemetered routinely via satellite or telephone to the National Tidal Data Base.

The stations will be connected to the Australian Height Datum by high precision levelling and to a universal reference system using GPS and VLBI technology. With this and repeated absolute gravity measurements absolute measurements of sea-level change will then be achievable. An appropriate level of resources and personnel will be required for maintenance, vertical datum control, and calibration.

Budget

Approximately $800,000 in capital equipment and installation, and a recurring expenditure of $186,000 annually for maintenance, data telemetry and operation of the data base.

Capital cost of setting up 8 baseline sea level stations, @ $100,000 per station	$800,000
Recurrent costs for local operation, maintenance, re-survey and calibration of 8 stations	$136,000/yr
Database maintenance (salary & operating)	$50,000/yr
Total	$186,000/yr + $800,000 (one off)

Contact: G. Holmes

D.1 Biospheric Inputs to Atmospheric General Circulation and Climate Prediction Models

CSIRO Division of Wildlife & Ecology, Division of Atmospheric Research
Centre for Environmental Mechanics, Division of Water Resources

Background

The exchange of heat and water vapour between the atmosphere and the biosphere (soil and vegetation) exerts a major influence on climate. In turn, the biosphere is modified by long-term climate changes, particularly in temperature, solar radiation, rainfall and CO_2 concentration. GCMs currently used in Australia have little or no representation of the biosphere and the biosphere-climate interaction, while some biosphere schemes in use overseas are quite complicated but not necessarily realistic.

Rationale

A biosphere model at even the crudest level must include both physics (heat and mass transfer between the surface and the atmosphere) and biology (stomatal behaviour and plant growth). Both types of process must be represented in a spatially-averaged way for each GCM grid cell (typically 250x250 km), taking into account the range of surface types within the cell. At present there is no work underway in Australia on the modelling of biosphere-climate interaction for incorporation in GCMs.

Specific Objectives

(1) To develop a physically and biologically sound biosphere model, suitable for use in GCMs, and incorporating aerodynamic roughness, albedo, evapotranspiration and primary productivity;

(2) To test the response and sensitivity of the GCM climate predictions to biospheric parameters, taking into account biosphere-climate feedbacks.

Description of Project

This would operate on two simultaneous, interacting tracks associated with the two objectives, and centred at CEM and DAR while DWE plays a key role in the biological research. The first track will incorporate present knowledge into a suitably comprehensive biosphere model, accounting where appropriate for the need for grid-scale averaging of surface properties. The approach will involve collation of scientific information, progressive development of a detailed biosphere model incorporating biological control of surface exchange fluxes, and the effects of inhomogeneity and local advection within grid cells. Evaluation of this model against existing "ground truth" data will be necessary. The second track will test the sensitivity and response of selected GCM climate predictions to the nature of the biosphere model and parameters, beginning with a relatively simple, but realistic, scheme incorporating biological control on evaporation at the surface (even this would be a substantial improvement on current GCM use). At an early stage, an assessment of overseas GCM biospheric systems will be necessary.

Timetable

The project as presently planned would require a minimum of 3 years with a possible extention to 4. The tracks run concurrently and with substantial interaction between all three Divisions.

Staffing

Two 3-year RS positions (one based at DWE, one at CEM), each interacting with available expertise (Raupach, Finnigan at CEM; Dunin, Passioura at DPI; Garratt, Hunt at DAR; Farquhar at ANU; Graetz at DWE; Kalma at DWR).

Special Needs

Access to a supercomputer and a GCM is vital.

Budget

Salary and on-costs (2 RS)	$120,000	per year + $60,000 one-off costs
Operating	$50,000	per year
Total:	$170,000	per year + $60,000 one-off (phasing in of this program is necessary

Contacts: R.D. Graetz, J.R. Garratt, M. Raupach, J.D. Kalma.

D.2

Climate Change and Water Use Efficiency

CSIRO Centre for Environmental Mechanics, Division of Plant Industry,
ANU Research School of Biological Sciencess

Background

Perceived climate changes include measured temperatures, altered humidity levels, and increased atmospheric CO_2 concentrations. All will affect plant productivity: the first two through direct effects on evaporation rate (and indirect effects on plant physiology); the last through effects on both evaporation and plant photosynthetic rates. The net effect on plant productivity can be measured in terms of water use efficiency - the water used per unit of plant material produced.

Rationale

There have been several recent attempts to measure the water use efficiency in enclosures enriched with CO_2. Recent work by us lead to paradoxical results suggesting that great circumspection was needed in attributing the observed differences in efficiency to the increased CO_2. This project seeks to examine CO_2 uptake and water use in wheat under adjacent field and enclosure conditions. It will pay proper attention to how the extensive wheat crop modifies its environment including advective effects.

Objectives

To compare field and enclosure measurements of water use efficiency under realistic field conditions of advection and produced modifications of the environment.

Description

The project will be conducted in collaboration with the Research School of Biological Sciences ANU who have extensive expertise on the enclosure technique. The task will be to measure the water use efficiency of the wheat crop under natural conditions, disentangling the relative contributions of transpiration and soil evaporation, and making proper allowance for the advective changes and the plant modification of its environment (both spatially and temporally).

Timetable

The field work will be conducted in conjunction with a joint CEM-RSBS Wheat Board funded project examining water and efficiency study of relative evaporation from soil vs transpiration by the crop. It will involve simultaneous observations of photosynthesis and water use by the eddy correlation method and enclosures. The field phase would be the summer of 1989 with the preceeding year used for preparation of instrumentation/software and theory and the subsequent year(s) devoted to data analysis and publication. The expected results will be a definitive statement as to whether the results of the enclosures with enhanced CO_2 to provide a realistic prediction of water use efficiency of a major world crop. The project will also involve the revival of the world standard experimental research at DPI into physiological aspects of CO_2-water use efficieny relationships.

Staffing

2 post-doctoral fellows for CO_2 measurements, programming and data analysis one each at CEM and DPI.

Special Needs

High speed CO_2 sensor (the Division is acquiring one with Institute support and a second upgraded version will be required for this project).

Budget Costs

2 Post-doctoral fellows for three years (including super and operating costs)	$80,000 per year
Upgraded fast CO_2 sensor	$50,000
Travel and field equipment	$40,000 per year plus $50,000
Total:	$120,000 per year plus $100,000 (one off)

Contact: O.T. Denmead, R.M. Gifford

D.3 Satellite Monitoring of Australian Region Climate Change

CSIRO Division of Atmospheric Research, Division of Wildlife & Ecology

Background

A major and fundamental component of the international effort on climate concerns gathering data on the present state of the earth-atmosphere- ocean systems to an extent and accuracy sufficient not only to detect change but also to use as input and verification for climate forecasting models. The state must be defined in terms of surface parameters which are of direct relevance to human affairs (biological activity, frequency of significant weather events, temperature, land condition etc etc) as well as those parameters primarily of concern for verification of the modelling of atmospheric processes (cloud cover, aerosols and overall system dynamics).

Rationale

The statistics of surface variability are such that as a general rule the only feasible method of obtaining sufficiently accurate and comprehensive data on climate is via remote sensing from satellites. The concentration must be on operational satellites since the need is for long-term monitoring of change. It is necessary as well (since the international effort has its own priorities) to concentrate on those climate variables - and on space and time scales - which are of particular concern to Australia.

Specific Objective

To provide operational techniques and demonstration data sets for monitoring climate variables for the Australasian region from operational meteorological satellites. The first major milestone will be the production of a demonstration 'atlas' of satellite-derived product for one year in 1991-92. To (re)map Australian landscapes into units that are homogeneous with respect to aerodynamic roughness, levels and seasonal dynamics of albedo, evapotranspiration and primary productivity

Description of Project

The basis of the project has been laid over the past five years by the development of the satellite reception and data analysis facilities at DAR, DO and DWE. Those parameters which can be monitored, or can potentially be monitored, by meteorological satellites have been identified. Work has begun on the coherent development of techniques and algorithms for monitoring such things as: surface temperature (both land and ocean); vegetation indices of various types; frequency of frost and fog; surface moisture; rainfall; cloud cover; frequency and extent of forest fires; surface albedo; atmospheric dust and aerosol; etc etc. A major component of the work will be the development of techniques for the automatic assembly and compositing of the ultimate data product.

Timetable

Technique and Algorithm Development	1989-1991
Upgrading of Computing Facility for automatic data assembly	1990-1991
Demonstration 'Atlas'	1991-1992
Transference of techniques to operational status	1992-

Staffing

Eight DAR and DWE research and experimental scientists are currently involved in the project on a part-time 'as available' basis. (Staff from DO are also actively involved). Their activity is severely limited not only by time but also by the lack of experienced programmers capable of professional installation of algorithms and software infrastructure on the CSIDA satellite reception and analysis system. The minimum requirement is for 1 experimental scientist to be fully devoted to system implementation at DAR and an ES and TO to work with existing research staff at DWE.

Budget

Salaries and on-costs (2 ES, 1 TO)	$120,000	per year
Operating	$55,000	per year
Capital equipment requirement (1989-91)	$150,000	
Total	$175,000	per year + $150,000 (one-off)

Contact: G.W. Paltridge, R.D. Graetz

D.4 Implications of Climate Change for Ground Water Recharge, Rainfall and Temperature

CSIRO Division of Water Resources

Background

Changes in rainfall, temperature and CO_2 will have significant impacts on all aspect cycle. Indeed, models predict that on average over the Earth, precipitation will increase by about 10%. However, such changes will be extremely regional. Combined with temperature effects on evaporation, the available water in stream runoff, ground storage or soil moisture will be very regionally dependant and of great economic and environmental importance.

Rationale

It is likely that quite small changes in any of the climatic parameters mentioned above will have quite large effects on, for example, groundwater recharge or surface runoff. While the predictions of climatic change on a regional basis are as yet poorly developed, we need to develop a predictive capacity to assess hydrologic impacts of the changes, when regional climate change models become available. The water resource industry is a multi billion dollar enterprise (eg MMBW sales are approximately $1B per annum). As this industry has long planning lead times, early assessment of the water resource implications of climatic change is essential. As an example of the possible effect of a change in rainfall, early work by us has suggested that a 10% decrease in rainfall may lead to a reduction in groundwater recharge of up to 50%. Work by Aston has suggested that increasing CO_2 concentrations may cause a considerable increase in stream runoff.

Specific Objectives

To develop techniques which can be used to estimate the impact of a range of possible climatic scenarios on groundwater recharge and related processes. We will also use taxonomic techniques developed in the Division to examine the hydrologic response of catchments. The methodology enables "hydrologic noise" to be reduced and allows trends in catchment runoff to be studied. Any changed trends in such runoff will signal the onset of the effects of climatic change.

Description of Project

A mechanistic model which takes soil-plant-atmosphere interactions into account, has been partially developed. This will be used to simulate the effects on groundwater recharge of possible changes in climatic parameters.
In the taxonomic work, long term (approx. 100 years) rainfall and temperature records will be analysed for consistent patterns and trends. From the data a number of indices will be developed and patterns in these in time and space will be evaluated.
Techniques for this application of numerical taxonomy are currently being developed using data from the Hunter Valley in NSW.

Staffing

Present staff:

Body	(30%)
Cook	(50%)
Goodspeed	(20%)
Sharma	(50%)

Timetable

The present Hunter Valley work will reach publication stage in 3 months. A further 2 years will be required to extend the research Australia wide. The recharge component should run for 2-3 years.

Budget

Salaries and on-costs 1RS, 2TA)	$120,000	per year
Operating	$50,000	per year
Total:	$170,000	per year

Contact: G.B. Allison

CONSULTATION

The following are the full comments from agencies consulted:

Attorney-General's Department

1. The Attorney-General's Department supports the Submission. International action on climate change is assuming greater scientific, political and legal importance.

2. The Attorney-General's Department notes that some international attention in the climate change field is being, and will be, devoted to the development of new legal instruments. These instruments will provide a useful focus for the development of international law on transboundary pollution and the development of atmosphere law at large. In this context, private and public law liability questions and the settlement of international disputes are important matters. The Attorney-General's Department has a policy role in connection with such matters. It consequently has a role in the proposed Commonwealth Inter-agency Committee and also in connection with national and international meetings where such matters are considered.

Australian Science and Technology Council

3. ASTEC supports the thrust of the Submission. In particular ASTEC supports the proposed changes to the role of the National Greenhouse Advisory Committee. As the Council advised in its earlier co-ordination comment, the research grants program must be planned to ensure that priority areas receive attention and that resources are used effectively.

4. While acknowledging the need for flexibility in responding to the climate change issue, ASTEC considers that a forward commitment to 1991/92 is necessary to support the enhanced climate modelling work of CSIRO and the Bureau of Meteorology. Both organisations will be seeking to attract high-calibre climatologists and computer experts from abroad, for which an assurance of longer-term funding will be required.

Department of Community Services and Health

5. The Department of Community Services and Health has no co-ordination comment to propose and supports the submission.

Department of Defence

6. The Department of Defence agrees with the recommendations. The strategy set out in Attachment D is supported, noting that research should place emphasis on prediction and measurement of greenhouse climate change and its effects in the Australian region and not

duplicate research being done elsewhere. Australia should participate in international research and other activities to the extent necessary to sustain Australia's influence in the development of international policies and strategies. Australia would be expected to contribute to world research also where it had unique research capabilities.

Department of Employment, Education and Training

7. The Department of Employment, Education and Training believes that the Government should make a strong commitment to addressing the greenhouse issue both nationally and internationally and that this commitment should be backed by an active research program focused on Australian interests.

8. The level of funding should be considered in the context of other requests for funding for science and technology. Any new funding scheme should be developed in concert with existing granting schemes in DPIE and the ARC.

Department of Finance

9. Finance questions the need to consider all aspects of the proposed strategy at this juncture. There could be merit in concentrating on the core research issues (with CSIRO having the main role) for now with a view to establishing firmly the extent of any climate problem before entering too far into the development of long-term administrative arrangements and policy solutions which may not be well directed.

10. It would seem appropriate that funds for the research requirements be examined against other new spending proposals outlined in the accompanying Submission on science funding (CS 6352) and the various associated current reviews on science and technology. This could be handled in the 1989-90 Budget context.

11. Other aspects of the proposed strategy, such as DASETT's involvement in international forums, promoting community awareness etc, could be regarded (at least for the present) as activities for funding from within existing portfolio resources according to priorities.

Department of Foreign Affairs and Trade

12. The Department of Foreign Affairs and Trade supports the general thrust of this Submission, recognising that the consequences of the greenhouse effect will have a significant impact on Australia's strategic, economic, social and political interests both at home and abroad. A co-ordinated and informed response to climate change is therefore vital to the preservation of Australia's economic strength, security and values. The Department of Foreign Affairs and Trade therefore supports the proposals for additional and co-ordinated research and policy development contained in the Submission. We should also wish to make the following points:

- The Submission deals with issues surrounding the Greenhouse Effect which go beyond Australian domestic concerns and which are also the subject of Submission number 6255 on International Environment Issues. Elements of the Submission's subject matter are relevant to DFAT's portfolio responsibilities for international relations, international trade policy, international negotiations and its central role in relation to treaties. The Submission also contains funding proposals for international organisations and activities which may affect AIDAB's responsibility for overall co-ordination of international development assistance allocations.

- We therefore consider that care will need to be taken to ensure that there is no duplication between the proposals in this Submission and those in Submission number 6255.

- Most notably, the responsibilities of proposed "Commonwealth Inter-Agency Committee", convened by DASETT which would, inter alia, "assume responsibility for co-ordinating Australia's input into the WMO-UNEP Intergovernmental Panel on Climate Change (IPCC)" need to be defined more clearly to distinguish them from those of the "Interdepartmental Committee to develop positions on international environmental issues" proposed in Submission number 6255. It should be made clear that the Inter-Agency Committee proposed in this Submission will be responsible for Greenhouse issues: the Interdepartmental Committee proposed in Submmission number 6255 would be concerned with the broad range of international environmental issues (eg. sustainable development, hazardous wastes, pollution, deforestation, desertification, biodiversity, negotiation of legal instruments including on climate change and protection of the atmosphere, etc).

- The Submission also contains proposals for funding under DASETT co-ordination to enable Australia to actively participate in the developing of international activities, including through the secondment of experts to relevant intergovernmental organisations. It should be noted that these proposals are additional to the proposals in Submission number 6255.

- DFAT is concerned about the way in which the Submission deals with the economic and trade implications of the greenhouse effect, notably in paragraph 5 of the media strategy outline (Attachment A, Appendix 1) which seeks to downplay these aspects in Ministers' responses to questions on the issue. While there may be a valid point to be made about the domestic sensitivities involved, we feel that the economic and trade implications of the greenhouse effect are so significant that they must be faced squarely. Industry groups and sectors

of the community who are likely to be most affected are well aware of the implications. Unless the Government is seen to address these issues in a realistic manner, it would quickly draw criticism from these groups. In our view, the trade and economic consequences of the greenhouse effect have the potential seriously to affect the quality of life of all Australians.

. We are also concerned that references in the media strategy could be more carefully crafted. For example, in Attachment A paragraph 5, page 10, the two first dot points, may draw the response that Australia is the world's largest exporter of coal.

Department of Immigration, Local Government and Ethnic Affairs

13. The Department of Immigration, Local Government and Ethnic Affairs supports the general thrust of the Submission.

14. Local Government, because of its responsibilities for planning, approval and provision of local infrastructure and development, including housing, has a concern that its decisions, from an amenity and liability perspective, are able to take into account changing environmental conditions such as those possible through the greenhouse effect.

15. DILGEA would want the proposed National Greenhouse Advisory Committee, and any proposed research program, to also address the implications for Local Government planning, infrastructure provision and development approval processes.

Department of Primary Industries and Energy

16. The Department of Primary Industries and Energy supports the broad thrust of the Submission's recommendations. It notes that DPIE has responsibility for significant aspects of greenhouse research and major responsibilities for the development of policy responses on limiting the causes of greenhouse emissions and adjusting to the impacts of greenhouse induced changes. However, DPIE staffing and financial resource requirements to meet the heavy workload inherent in the submission's proposals are not addressed.

17. With respect to research, DPIE is involved through the work of the Bureau of Rural Resources (BRR) and Mineral Resources (BMR) on climate modelling (eg. the role of BMR in researching the historical concentrations of greenhouse gases) and the work of BRR, rural industry research councils and the National Energy Research Development and Demonstration Council in the areas of causes and impacts of greenhouse.

18. DPIE's responsibilities with respect to energy production, consumption and trade, agricultural production and trade, and forestry are key areas for

formulating policies on limiting the causes of greenhouse emissions.

19. These areas, and other DPIE responsibilities involving fisheries, water and soil research management, are key areas for developing policy responses on the impacts of greenhouse.

Prime Minister and Cabinet

20. The Department of Prime Minister and Cabinet notes that if some of the forecasts of climate change made by credible scientific authorities come to pass, then this issue has the potential to generate the most significant social, economic and political problems likely to confront Australian Governments over the next two decades.

21. Internationally, the loss of land, including through desertification, may require the relocation of populations on a scale not previously encountered.

22. PM&C therefore supports efforts to co-ordinate and enhance local research and co-operation with international efforts to understand and respond to the problems which climate change may generate.

23. In these circumstances, PM&C believes that the research effort should be focused on key strategic issues, so as to provide a foundation for appropriate policy responses. Given the potential impact of climate change, PM&C notes that research will need to proceed concurrently on the nature and extent of climate change (ie. determining if there is a problem) and its causes, as well as developing responses to the range of potential problems.

24. Given the significance of the issue to a range of portfolio interests, PM&C is concerned that consultation mechanisms are designed to allow an appropriate weight to all interests, and are consistent with the general approach taken by the Government to science policy. PM&C also considers that it is important that the Government's broad policy priorities be communicated to the National Greenhouse Advisory Committee when it is tasked with bringing forward recommendations on priority areas for research and that there be full opportunity for those policy considerations to be taken into account when final decisions are being taken on the level and allocation of research grants.

25. As to the question of additional resources for research, PM&C supports additional funding in 1988-89 to allow Australian participation in international consultative groups and studies, but suggests that there would be advantage in requests for 1989-90 funding being considered by the Expenditure Review Committee of Cabinet in the first instance, consistent with normal practice. Funding for later years should be considered in the appropriate Budget-context.

Transport and Communications

26. The Department of Transport and Communications has no comment on the Submission.

Treasury

27. Treasury is concerned that there is a risk of wasting resources in funding additional programs given the uncertainties on basic facts available, and forthcoming from existing research. Australia already spends almost $14m annually on 'greenhouse effect' related research and the bulk of funding and research on the greenhouse effect is inevitably done by larger countries.

28. Therefore Treasury agrees with the recommendation that the National Greenhouse Advisory Committee set down objectives and priorities for future publicly funded research, and it should also examine the focus of current publicly funded research. This should help provide a careful assessment of the contribution that Australian programs can make to specifically Australian concerns.

29. Treasury considers that any increased work on this issue should be done by reallocating resources from other less pressing areas. Scope for such a reallocation appears possible given that Government research expenditure in Australia is relatively high in international terms.

30. The greenhouse effect is already a topical issue and a longer term publicity campaign to gain support for Government activities runs the risk of drawing forth even further calls on scarce public funds.