

Integrating ozone and UV research with climate change

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Abstract. This paper outlines the function of the National Science Strategy for Climate Change, and offers suggestions for priority needs and opportunities for ozone and UV research insofar as they contribute to a comprehensive climate change research strategy for New Zealand. The research priorities are offered as a basis for further discussion with researchers and policymakers.

Introduction

Research into the ozone layer and effects of increased UV radiation on humans, plants, animals and building materials does not exist in isolation. In particular, there are strong scientific and policy links between ozone and climate change research, both in terms of overlap of work areas, human capacity, and sources of research funding.

Ozone and UV research are components of a research portfolio directed at increasing our understanding of the global atmosphere. Current and future research priorities within this overarching portfolio clearly lie in research into changes of the global climate which could result from human activities that produce greenhouse gases. The purpose of this paper therefore is to outline the key scientific linkages between ozone and climate change research, and to propose an explicit set of priorities for ozone and UV research as part of a wider climate change research strategy.

The links and priorities developed in this paper should be regarded as suggestions only, and feedback from scientists working in the field of ozone and UV research is actively invited to ensure that a comprehensive climate change research strategy is widely supported.

The National Science Strategy Committee for Climate Change

The National Science Strategy Committee for Climate Change (NSSCCC) was established in 1991 to:

- develop a strategy for climate change research, identifying priority research and gaps and appropriate funding levels,
- provide input into the FRST portfolio process and decision-making by other research funders,
- develop a portfolio of research with all interested parties,
- provide advice to government on the research necessary to underpin government's policy goals,
- monitor progress and implementation of the strategy, and advise government and funders of ways to strengthen this.

The current convenor of the NSSCCC is Judy Lawrence, CEO of the Ministry of Women's Affairs. The NSSCCC produces regular reports in which it outlines current scientific research activities in the area of climate change, and notes areas of priority to ensure that the

strategic objectives of climate change research in New Zealand are met (NSSCCC, 2001). The NSSCCC also holds regular workshops on topical issues to encourage communication between scientists, government agencies and other research end-users such as industry and local government.

Obvious linkages between ozone depletion and climate change research

Ozone/UV and climate change research have generally been treated as distinct phenomena in the public domain, largely to avoid misunderstandings and confusing messages being sent to the general public and policymakers. Nonetheless, some scientific linkages between the two fields have long been known, namely that:

- ozone itself is a greenhouse gas,
- most ozone depleting substances and substitutes (e.g. CFCs, HCFCs, HFCs) are strong greenhouse gases,
- some greenhouse gases that are not directly ozone-depleting can nonetheless affect stratospheric chemistry (e.g. CH₄, N₂O, and water vapour)
- changes in UV radiation can affect the tropospheric lifetimes and hence global warming potential of greenhouse gases,
- global warming by increasing greenhouse gas concentrations is likely to lead to stratospheric cooling and a warming of the tropical tropopause, which has the potential to significantly affect the composition and chemistry of the stratosphere.

In particular the latter point has received growing attention during the past decade, since stratospheric cooling caused by growing greenhouse gas concentrations would lead to an enhancement of reactions on aerosol surfaces and associated ozone depletion in mid-latitudes. At polar latitudes, this would also lead to a strengthening of the polar vortices and increased persistence of polar stratospheric clouds in time and space (WMO, 1998). The result of this could include enhanced polar ozone depletion, greater export of ozone-poor air to mid-latitudes at the break-up of the polar vortex, and/or a delayed recovery of the ozone hole over coming decades despite declining chlorine concentrations.

At mid-latitude regions, the overall effect of temperature on ozone destroying reactions depends on the balance between gas-phase and aerosol surface reactions. Gas-phase reactions would decrease in efficiency with reduced temperatures, whereas surface reactions on sulphate aerosols increase in efficiency. For low aerosol loadings as generally apply in southern hemisphere mid-latitudes, gas-phase reactions predominate, but this could change either as a consequence of long-term increase in anthropogenic aerosols, or after strong volcanic eruptions such as the Pinatubo eruption in 1991.

Temperature increases of the tropical tropopause would increase the amount of water vapour entering the stratosphere, leading to an intensification of some of the catalytic cycles involved in ozone depletion.

From a New Zealand perspective, the emerging evidence of an intrinsic coupling of the dynamics and chemistry of the ozone layer with greenhouse-induced global warming and climate change is of particular importance.

Firstly, the links demonstrate the need to maintain and increase connections in research activities and expertise in the two areas of science, including work conducted by formal international research networks and the less formal personal contacts held by New Zealand scientists.

Secondly, it is becoming increasingly evident that ozone and UV levels over New Zealand are affected by the chemistry and dynamics of the stratosphere over Antarctica and the surrounding latitudes (Connor *et al.*, 2002a; Bodeker, 2002). Global warming influences on polar stratospheric dynamics could lead to a delay in the recovery of the ozone layer, and to dynamics which would result in continued low-ozone events over New Zealand during summer time (Connor *et al.*, 2002b). Recent research by Thompson and Solomon (2002) also demonstrated the direct effect that the strength of the polar vortex may have on climate variability and change at southern hemisphere mid-latitudes.

Consequently there is a clear need for further research to identify the extent to which global changes in the temperature structure and/or chemistry of the upper atmosphere could have New Zealand-specific changes in seasonal weather patterns and UV levels.

Ozone and UV as part of a climate change research strategy

The NSSCCC is charged with developing a climate change research strategy. The following paragraphs therefore attempt to outline which UV and ozone research activities may be considered important to be undertaken in order to provide a comprehensive portfolio of climate change research. Research topics are grouped into the categories of “processes” (i.e. underlying science), “effects” and “responses”. It should be noted, however, that this perspective is clearly biased towards research relevant in a climate change context and may not capture other important reasons to carry out specific projects.

Processes. Because of the high relevance of polar and high-latitude atmospheric dynamics on both climate variability and UV levels over New Zealand, more research is needed to better understand the potential effect of greenhouse gases on ozone layer chemistry and dynamic feedback loops, and its impacts on future ozone and UV levels over New Zealand. Equally, the links between polar ozone depletion and recent climate variability as postulated by Thompson and Solomon (2002) warrant further attention as they can demonstrate the potential for regional climate changes caused by large-scale changes in atmospheric dynamics.

UV radiation and changes in stratospheric dynamics influence the tropospheric lifetimes of many greenhouse gases, and additional research may be required to improve estimates of global warming potentials for greenhouse

gases, which typically requires atmospheric model calculations over time spans of a century or more.

There is also an on-going need to assess the global warming potentials of CFC substitutes and other new synthetic gases as they are developed and enter the market, and to ensure that new gases are assessed for their impact on tropospheric chemistry.

Effects. Climate change and UV radiation both represent potential stresses on the environment in which plants and animals grow, and also on building materials. From a perspective of climate change, it is particularly relevant to identify synergies or mutual inhibitions between increased UV radiation and the ability of plants, animals and materials to cope with climate change.

For plants, climate change can represent both an opportunity (through CO₂ fertilisation and extended growing seasons), and a risk (through drought, salinisation, eutrophication, temperature stress). Increased peak summertime UV levels may alter the way plants respond to the effects of climate change, and may determine optimal adaptive response strategies by the agriculture sector.

Building materials, in particular plastics, are known to degrade under UV radiation, but also to show a strong temperature response. Recent research has started that can address the question of whether these responses are purely additive or may exhibit a synergistic behaviour (Jones, 2002), but additional efforts may be required to increase confidence in the lifetime of new materials under outdoor conditions at various locations around New Zealand.

UV radiation has positive and negative effects on human health. The most important adverse effect in New Zealand is that on skin cancer rates. Unless behaviours change, increased levels of UV radiation at the earth's surface will mean increased rates of skin cancer, but quantifying the increase in disease rates is subject to many uncertainties that include direct effects of climate change on UV levels over New Zealand, and climatic drivers of behaviour. Researchers overseas have attempted to model the impact of ozone depletion on rates of skin cancer (Martens, 1998), and there are opportunities to extend work of this kind to the New Zealand setting.

Responses. New Zealand has been highly successful in increasing public awareness of skin cancer risks and encouraging protective behaviours. These changes include sun-smart policies, such as tree-planting programmes in parks and re-scheduling outdoor activities in schools. Behavioural research in this area has a strong component addressing New Zealand-specific outdoor lifestyles and values which also relates to how we view and value our climate. Climate variability and long-term change, particularly any consistent greenhouse gas induced changes in seasonal weather patterns, could have a strong effect on behavioural UV exposure.

More generally, important lessons have been learnt in the course of skin cancer campaigns regarding public perceptions of environmental risks and management of those risks. These lessons should be studied carefully and inform the design of parallel work on communicating and

managing the risks of climate change for New Zealand.

The counterproductive fact that most CFC substitutes have a high global warming potential warrants further work to limit the negative impact of phase-out of CFCs in developing countries on global greenhouse gas emissions. A careful analysis of industrial uses of these gases may hold opportunities for replacing some powerful greenhouse gases with less damaging ones in specific applications.

The IPCC and Technological and Economic Advisory Panel (TEAP) to the Montreal Protocol held a joint meeting in May 1999 to explore coordinated actions that might be taken to address the problems of stratospheric ozone depletion and climate change (UNFCCC, 1999). The meeting recognised the complexity of the problem and potential solutions, including the need for solutions tailored to regional or national needs. This may include New Zealand participation in finding and contributing to solutions specific to the South-West Pacific region with its mix of developed and developing nations.

To the extent that plant species are negatively affected by increased UV radiation, and that climate change and UV may exhibit synergistic impacts, adaptive breeding of plants for UV resistance and tolerance may be an opportunity for some crops.

Finally, as mentioned previously, participation in international research networks offers to make best use of the synergies that ozone and climate change research naturally presents. In parallel, the lessons learnt and expertise gained in the area of scientific policy advice (through the WMO/UNEP assessment panels on ozone depletion, and the WMO/UNEP Intergovernmental Panel on Climate Change [IPCC]) would benefit from further and more explicit analysis and discussion by the research community.

In this context, it is a very encouraging sign that one of the leading researchers in ozone depletion, Dr Susan Solomon, has recently been appointed as co-chair for IPCC Working Group I, which focuses on the scientific basis of climate change.

Suggestions for specific New Zealand priorities

The above list of research issues which straddle ozone and climate, by no means complete, requires further condensing down to provide suggestions for New Zealand-specific priorities for research. The following paragraphs propose a list of topics in the area of ozone and UV research for further discussion by the scientific community and policymakers, in order to inform a comprehensive New Zealand research strategy on climate change.

Firstly, there is increasing evidence of the complex links between southern hemisphere dynamics in the troposphere and stratosphere, ozone levels over New Zealand, and feedbacks between polar ozone depletion, the strength of the polar vortex, export of ozone-poor polar air to New Zealand, and influence of the polar vortex on tropospheric circulation and climate variability and weather patterns. Research in this area is of high priority to allow seasonal climate predictions, estimates of long-term changes in UV levels as well as climate patterns, and the validation of

global climate models for attribution and projection of climate change.

Secondly, climate change is a problem of risk management under uncertainty, and of decision-making in domestic and international fora. Lessons from implementation of skin cancer awareness and protection programmes in New Zealand, and communication of the scientific evidence of ozone depletion, need to be analysed and where possible transferred to the area of climate change. This requires an interdisciplinary effort of social scientists, educators, and scientists and policymakers with personal experience. It would appear a loss of opportunity if the generation of scientists involved in ozone depletion research and policy advice retires without passing their experiences on to the next generation in their respective fields.

Thirdly, synergistic links between the effects of UV radiation and climate change on plants, animals, human health and building materials should be investigated with a specific emphasis on the New Zealand situation. It is unlikely that international research efforts will produce results relevant to, for example, New Zealand's agricultural practices, where plants may grow under higher UV levels than in other countries, could benefit from higher CO₂ concentrations and shifts in growing seasons, but also come under stress from droughts and competition with invasive species. Similarly, New Zealand building practices, climate and UV levels may not have an equivalent in other countries and hence cannot rely on overseas research. Similarly, the development of farm management systems that account for the impacts of climate change and a high UV environment, using "green" biotechnologies that are consistent with New Zealand's image could present relevant business opportunities.

Finally, New Zealand has been an outstanding and highly respected contributor to international ozone and UV research. Only some of New Zealand's prominence can be attributed to its important geographical position, but much is due to the competence of its scientists, their international connections, and the effective research programmes. It would appear useful to undertake a careful analysis of the history of ozone and UV research in New Zealand to be able to strengthen its most successful components in the related field of climate change.

Summary and conclusions

Scientific research into ozone and UV, and implementation of public policy to address the problem of ozone depletion, have been rather successful in New Zealand (although this paper does not attempt to measure this subjective notion of success in any way). Ozone depletion and climate change share the problem that they require sequential decision making under scientific uncertainty. This applies to participation in the international response (Montreal and Kyoto Protocols), domestic mitigation (phase-out of CFCs and reduction of greenhouse gas emissions) and adaptation (skin cancer protection and development of climate change adaptation), and building of public understanding and awareness.

Due to the scientifically more extensive and politically

more complex problem of climate change, public policy will continue to require extensive input from climate change science for decades to come. This concerns not only the development of solutions to reduce greenhouse gas emissions, but also to the need to deal with the inevitable surprises with which the climate system will challenge our understanding and efforts to adapt to the impacts of climate change.

It is obvious that not all lessons learnt in the area of ozone depletion may be readily transferable to climate change (Reisinger, 2002), and topics in the area of ozone/UV research obviously need to be balanced against other priorities in the wide area of climate change research within a limited funding environment. Nonetheless, the experiences gained over the past decades in ozone and UV research and their interaction with policy development are an invaluable resource. A careful and systematic analysis of successes and shortcomings of this research area, including the development of specific research programmes and the communication of research results in New Zealand, could be very useful to inform decisions regarding the direction and structure of on-going climate change research in New Zealand.

Acknowledgements and Disclaimer

This paper was presented by AR on behalf of the Committee's Convenor, Judy Lawrence, with contributions from Bruce Campbell, David Wratt, Alistair Woodward and Martin Manning. Nonetheless, all biases, errors or omissions are those of the author (AR). Many New Zealand scientists have provided their expertise and time to assist the National Science Strategy Committee for Climate Change in the development of its research strategy. The analysis presented in

this paper should be regarded as a starting point for discussions, not as a definitive analysis by the Committee.

This paper is not endorsed by, and does not necessarily reflect the views of any government agency or the New Zealand Climate Change Programme.

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