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The Ozone Layer

The Ozone Layer provides the first thorough and accessible history of stratospheric ozone, from the discovery of ozone in the nineteenth century to current investigations of the Antarctic ozone hole. Drawing directly on the extensive scientific literature, Christie uses the story of ozone as a case study for examining fundamental issues relating to the collection and evaluation of evidence, the conduct of scientific debate and the construction of scientific consensus. By linking key debates in the philosophy of science to an example of real-world science the author not only provides an excellent introduction to the philosophy of science but also challenges many of its preconceptions. This accessible book will interest students and academics concerned with the history, philosophy and sociology of science, as well as having general appeal on this topic of contemporary relevance and concern.

MAUREEN CHRISTIE is Lecturer in Philosophy of Science at the University of Melbourne, Australia.

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To the memory of Mary Agnes Christie
(14 February 1911 – 17 October 1996)

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Abbreviations

AAOE	Airborne Antarctic Ozone Experiment. A suite of experiments in the form of observations from two high-flying aircraft in the Antarctic region in August/September 1987.
AEC	Atomic Energy Commission. US government agency.
AES	Atmospheric Environment Service. Canadian government agency.
bpi	bits per inch. A measure of how densely data is recorded on magnetic tape.
CFC or cfc	chlorinated fluorocarbon. One of a series of artificial and unreactive chemical substances, first developed as refrigerants in the 1930s, and later in wide industrial and domestic use.
DU	Dobson unit. A measure of the integrated ozone concentration up a vertical column of the atmosphere. 100 DU corresponds to a layer of pure ozone gas 1 mm thick at 1 atmosphere pressure and 0°C.
EBCDIC	a protocol for binary coding of data, current in the 1960s and 1970s.
ENSO	El Niño Southern Oscillation. A climatic phenomenon affecting mainly the Southern Pacific region, where a pool of warm water develops off the Western coast of South America, and disrupts normal climate patterns.
IDL	Interactive Data Language. A software system used by NASA in analysing satellite data.
IGY	International Geophysical Year. A period in 1957 and 1958 set aside by UNESCO for a special international effort in geophysics research.
NAS	National Academy of Sciences. US organisation.
NASA	National Aeronautics and Space Administration. US government agency.
nm	nanometres. 1 nanometre is a millionth of a millimetre. The unit is commonly used for the wavelength of visible light (range to 700 nm) and ultraviolet light (range about 50 to 400 nm).

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x	List of abbreviations
NOAA	National Oceanic and Atmospheric Administration. US government agency.
NOx	A term used by atmospheric scientists for the total atmospheric content of all of the reactive oxides of nitrogen, that is all nitrogen oxides except for nitrous oxide, N ₂ O.
NOZE	National Ozone Experiment. Two US scientific expeditions to Antarctic, specifically set up to conduct a number of upper atmosphere observations in August 1986 and August 1987.
ppbw and variants	parts per billion by weight. The fourth letter may also be a 'v' for parts by volume. The third may alternatively be 'm' for million, or 't' for trillion. The billion and trillion are American billions and trillions, 10 ⁹ and 10 ¹² respectively.
QBO	Quasi-biennial oscillation. A semi-regular climatic pattern seen in changing direction of the prevailing airflow at the equator. The pattern repeats with a period ranging from about 24 to 32 months.
SBUV	Solar back-scattered ultraviolet. A satellite-based series of instrumental observations which provides ozone data.
SST	Supersonic Transport. A term for the various projects seeking to produce supersonic passenger aircraft.
STP	Standard temperature and pressure. Because gases are very compressible, concentrations depend sensitively on temperature and pressure conditions. Gas properties are often converted to STP – the properties the gas would have at 0°C and 1 atmosphere pressure.
TOMS	Total ozone monitoring spectrometer. A satellite-based series of instrumental observations of ozone data.
UT	Universal Time. Typically measured in seconds after midnight Greenwich Mean Time, or as a simple alternative to GMT.
UV	Ultraviolet. Refers to light whose wavelength is shorter than visible light. Often divided for medical purposes into UV-C, UV-B, and UV-A in order of shortening wavelength, and increasing danger from bodily exposure to the radiation.
VAX	A mainframe computer dating from the early 1970s.
WMO	World Meteorological Organisation. A United Nations agency.
WODC	World Ozone Data Centre. The world repository for ozone data. Hosted by the Canadian Atmospheric Environment Centre at Downsview, Ontario, under a WMO United Nations charter. It has now become WOUDC: World Ozone and Ultraviolet Data Centre.

Preface

When choosing a topic for my doctoral studies in the History and Philosophy of Science, I wanted to do something that was important to our understanding of the way science works. I was also anxious to avoid the musty and much-travelled corridors of European science of a century or more ago. It was important to me that my topic should have strong relevance to today.

I became interested in stratospheric ozone, CFCs, and the Antarctic ozone hole when my husband John, who is a chemist, outlined a new course of lectures he was preparing. I asked him if I could sit in on his lectures. As the course unfolded I became enthralled with the topic. I hope that in presenting this very rich history of stratospheric ozone, and the scientific investigation of the Antarctic ozone hole in this way, and relating it to some consideration of how scientists collect and evaluate evidence, I will have provided material of great interest and value for all who read these pages.

This book is an extension of the work in my doctoral thesis. I am greatly indebted to my husband, Dr John R. Christie, for his help, support, encouragement and for his long-suffering patience. As a scientist himself, he has been a very wonderful resource and this book would never have been written without his help. I would like to thank him for the many hours he gave me and for the very many valuable discussions we have had. He has made many valuable contributions towards getting this book together, which should not be overlooked. They included helping me with the knobs and whistles on our computer software, and, more importantly, invaluable help with, and contribution to, the more technical aspects of the chemical discussions.

I would also like to thank Dr Neil Thomason. Neil supervised my doctoral work. He also took much of the initiative in getting my work brought to the notice of the publishers. He catapulted me into taking effective steps to produce this volume, by arranging an interview for me with Catherine Max (formerly of Cambridge University Press). I would also like to thank Catherine who did much to encourage me. She was always

very positive and enthusiastic. All the staff at HPS Department at the University of Melbourne have also been very supportive.

I would like to thank several scientists who granted me some of their very precious time and who were all very generous to me. They include Jonathan Shanklin from the British Antarctic Survey, Dr David Tarasick, from Environment Canada, Dr Susan Solomon, NOAA, Boulder, Dr Adrian Tuck, NOAA, Boulder, Professor Harold Johnston and his wife Mary Ella, of Berkeley, Dr Charles Jackman and Dr Rich McPeters, both of NASA Goddard Space Flight Centre.

I would like to thank my extended family, Peter and Suzie, Wendy and John, Phil and Karen, and Steve. I would especially like to thank my five lovely grandchildren, Tristan Richards, Orien Richards, Shannon Richards, Danielle Barker and Jocelyn Barker. They provided a much needed source of joy and distraction.

And last but not least: the book has been dedicated to the memory of my very lovely mother-in-law and special friend, Agnes Christie. She was a great source of encouragement not only to me, but to all who knew her. I undertook university studies as a mature age student and Agnes was so supportive, and very proud of me. She passed away just six months prior to the completion of my doctoral work.