New Zealand National Report

for the 9th WMO/UNEP Ozone Research Managers Meeting

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Introduction

In New Zealand, ozone- and UV-related research takes place at the National Institute of Water and Atmospheric Research (NIWA), at Bodeker Scientific, and in several of our Universities. Many relevant observations are taken at Lauder, near Alexandra. This station is a global station in WMO's Global Atmosphere Watch Programme, and also is part of the Network for the Detection of Atmospheric Composition Change (NDACC). Ozone, as well as a number of parameters related to ozone depletion, are measured with a variety of techniques such as Dobson spectrophotometry, UV-visible spectroscopy, infrared spectroscopy, microwave radiometry, electrochemical ozonesondes flown on balloons, ozone and aerosol lidars, and frostpoint hygrometers. Solar UV radiation is measured at a number of sites. There also are measurement activities outside of New Zealand, such as in Antarctica and Pacific Islands. Specific work in support of environmental conventions also is taking place. Due to its location in the Southern Hemisphere and proximity to Antarctica, New Zealand is particularly interested in the climate effects of stratospheric ozone depletion. The newly approved "Deep South" National Science Challenge is a newly funded 10-year research programme with the aim of better understanding how changes in the Antarctic region affect New Zealand; the effect of ozone depletion and recovery on climate will form part of this programme.

Projects and Collaborations:

National Projects

Ozone and related research in New Zealand is undertaken primarily through the New Zealand Regional Atmosphere programme, which includes various measurement activities of ozone and associated species, primarily at Lauder, New Zealand, and Arrival Heights, Antarctica, measurement of physical variables such as UV, as well as global chemistry-climate modelling. UV measurements at Lauder are part of a larger research effort, spanning the physical and medical sciences communities, on the impact of UV on human health (both positive and negative effects), materials, and the biosphere. This research is informing health organizations such as the New Zealand Cancer Society.

International Projects

Ozone research in New Zealand is undertaken in close collaboration with many international partners and contributes to a wide range of international projects. Selected current international projects are:

NDACC (Network for the Detection of Atmospheric Composition Change), for which Lauder is the primary southern mid-latitude site, has been the principal focus of ozone-related work by NIWA at Lauder for more than three decades. NIWA reports a variety of profile, total column, and surface in-situ measurements of ozone and associated species to NDACC, taken at its primary locations at Lauder, NZ, and Arrival Heights, Antarctica, and also UV/Vis measurements of total-column NO2

from Macquarie Island, Australia, taken in collaboration with the Bureau of Meteorology, and Mauna Loa, Hawaii, in collaboration with NOAA.

IGAC/SPARC CCMI (Chemistry Climate Modelling Initiative): Contributing CCM simulations to the CCMI archive and participating in process oriented validation of CCMs. CCMI is the latest in a series of chemistry-climate modelling activities involving NIWA; previously, NIWA contributed to CCMVal-1 (informing the 2006 WMO Ozone Assessment), CCMVal-2 (informing the 2010 Ozone Assessment), and ACCMIP (informing the 5th Assessment Report of the Intergovernmental Panel on Climate Change, IPCC, on tropospheric composition change). Unlike these predecessor activities, the aim of CCMI is to perform and assess whole-atmosphere chemistry-climate model simulations that will inform upcoming ozone, tropospheric air quality, and climate assessments, all with the same class of model. NIWA is participating in the development of the MetOffice Unified Model which, in different versions, has been used for all of these purposes, and is also working with Australian partners on their contribution to CCMI, using the ACCESS model.

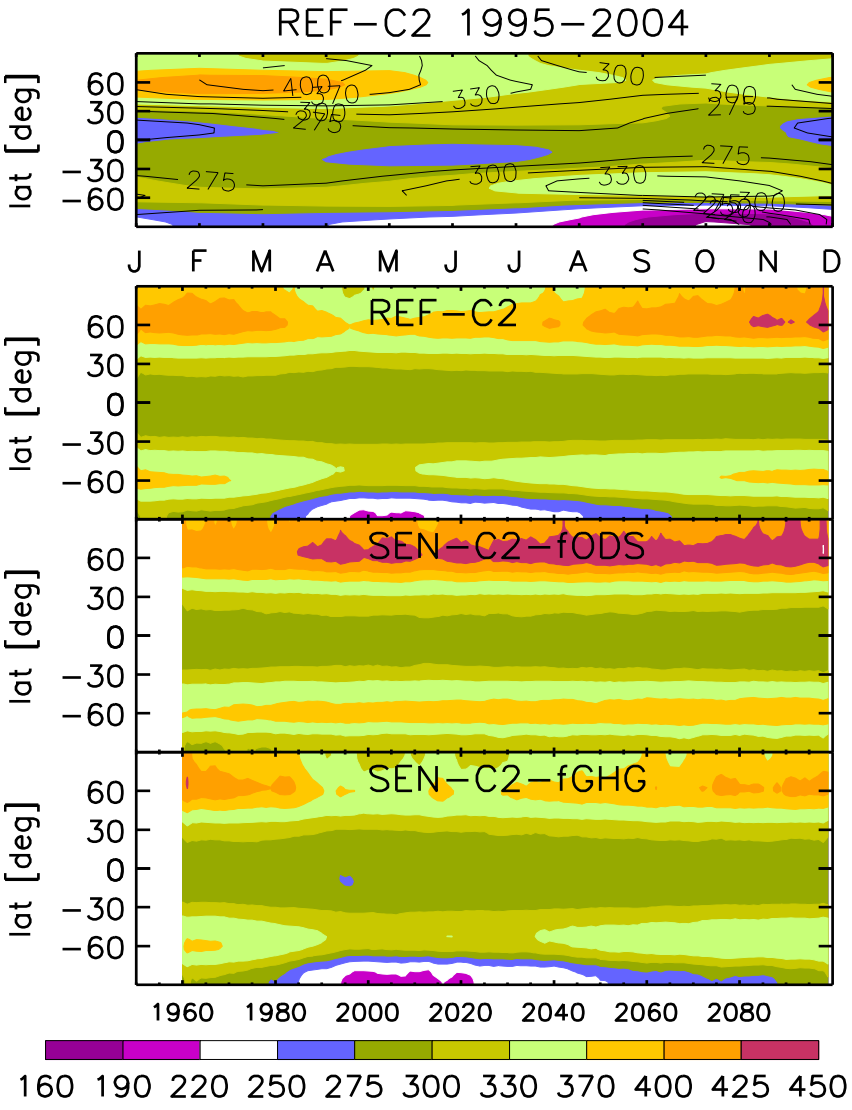

Figure 1: Zonal-mean total column ozone (Dobson Units) in the NIWA chemistry-climate model. (top) 10-year mean for present-day conditions (contours: TOMS/SBUV climatology). (bottom 3 panels) Annual-mean ozone column in all-forcings, fixed-ozone depleting substances, and fixed greenhouse gases simulations.

GRUAN (GCOS Reference Upper Air Network): Measurements of ozone, water vapour and meteorological parameters using ozonesondes and high-standard radiosondes. This is done on contract with NOAA and the New Zealand Metservice. In support of this activity, NIWA has changed aspects of the method of conducting ozonesonde flights, has brought in a Global Positioning System (GPS) instrument which produces, as a by-product, total-column water vapour, and is using improved radiosondes giving more accurate readings of temperature and pressure.

BSRN (Baseline Surface Radiation Network): Various measurements of radiation, particularly of UV, are supplied to this international network.

SAGE-III Validation: Validation campaign, planned for 2015, of ozone and aerosol soundings, to validate the SAGE-III instrument on board the International Space Station, on contract with NASA.

National collaborators

NIWA

Richard Querel, Lauder: Ozone measurements project manager; GRUAN

Olaf Morgenstern, Lauder: Programme Leader – New Zealand Regional Atmosphere; Chemistry-climate modelling

Guang Zeng, Lauder: Chemistry-climate modelling

Alan Thomas & Hamish Chisolm, Lauder: Ozonesonde project, Dobson measurements

Dan Smale, Lauder: TEI and FTIR in situ ozone measurements

Sylvia Nichol, Wellington: Dobson measurements

Hisako Shiona, Christchurch: Dobson measurements, ozonesonde project, chemistry-climate modelling.

Adrian McDonald, University of Canterbury: Stratospheric ozone and dynamics, model analysis.

Tony Reeder, University of Otago: Effects of UV overexposure in humans.

Martin Allen, Univ Canterbury: UV dosimetry

Barbara Hegan, Cancer Society: UV Public health advisory

Karin Kreher, Bodeker Scientific: UV/Vis measurements of atmospheric composition

Greg Bodeker, Bodeker Scientific: GRUAN, simplified ozone chemistry

Robert Scragg & Alistair Stewart, Univ Auckland: UV, vitamin D and Health

Kathy Nield & Neil Swift, Callaghan Institute/MSL: Irradiance calibration issues

Martin Allen, Univ Canterbury: Dosimeters

Zim Sherman, Scienterra, Timaru: Dosimeters

Australian collaborations

Peter Gies, Australian Radiation Protection and Nuclear Safety Authority: UV and behavioural studies

David Griffith & Nicholas Jones, University of Wollongong: Collaboration on FTS measurements, especially related to biomass burning

Bruce Forgan, Bureau of Meteorology: Spectral and broadband radiation and aerosols

David Karoly, U Melbourne: Collaboration on coupled chemistry climate modelling

Andrew Klekociuk, Australian Antarctic Division: Collaboration on coupled chemistry-climate modelling.

Janet Bornman (Curtin, Australia), United Nations UNEP: Environmental Effects of UV radiation

Robyn Lucas (ANU): UNEP also UV Workshop

Peter Gies (ARPANSA), Michael Kimlin (QUT): UV Workshop

USA and Canada collaborations

NOAA

Dale Hurst, GMD: Funder and co-investigator on frost point hygrometer flights at Lauder, provision of surface ozone instruments, data sharing and interpretation

Patrick Disterhoft, CSD, CUCF: Global variability of UV (Mauna Loa and Boulder), Calibration of spectroradiometers

Robert Evans & Irina Petropavlovskikh, GMD: Dobson total-column ozone measurements

GMD = Global Monitoring Division (was CMDL); CSD = Chemical Sciences Division (was aeronomy laboratory); CUCF = Colorado Ultraviolet Calibration Facility

NASA

Richard McPeters, GSFC: Provision of Total Ozone Mapping Spectrometer (TOMS) satellite-based total column ozone measurements

Jay Herman, GSFC: Validation of satellite derived UV, UV units

Larry Thomason, LaRC: Provision of Stratospheric Aerosol and Gas Experiment (SAGE) satellite-based measurements of trace gases and aerosols. Lead investigator of the SAGE-III campaign.

Michael Kurylo, NDACC: NDACC data archival, meta data

Qing Liang, Margaret Hurwitz, Paul Newman, GSFC: Chemistry-climate modelling

GSFC = Goddard Space Flight Center; LaRC = Langley Research Center; NDACC = Network for the Detection of Atmospheric Composition Change

USA Universities

Wei Gao & Marek Uliasz, Colorado State University/USDA: Global variability of UV, USDA radiation suite; collaboration on dispersion modelling

Alan Parrish, University of Massachusetts: Co-investigator on microwave radiometers for ozone profiling

Darryn Waugh, Johns Hopkins University: Collaboration on chemistry-climate modelling

USDA = United States Department of Agriculture

Other USA and Canada

Gerald Nedoluha, Naval Research Laboratories (NRL): Co-investigator on microwave radiometers

R Booth & G Bernhard, Biospherical Instruments: Validation of UV from spectrometers

Sasha Madronich, NCAR: TUV Radiative transfer model, aerosol studies, UNEP

Sancy Leachman, Utah: UV dosimeters and health

Tracy Petrie, Oregon: UV dosimeters and health

Charles N. Long, Pacific Northwest National Laboratory (PNNL): Radiation Studies

Vitali Filetov, Environment Canada: UVI

NCAR = National Center for Atmospheric Research

United Kingdom collaborations

Martyn Chipperfield, University of Leeds: Collaboration in chemical modelling

Neal Butchart & Fiona O'Connor, UK Met Office: Collaboration on chemistry-climate modelling

John Pyle, University of Cambridge: Chemistry-climate modelling

Ann Webb (and several others), Univ Manchester: Rationalising UV units for CIE

Collaborations with rest of Europe

Jordi Badosa, Laboratoire de Meteorologie Dynamique (LMD), Ecole Polytechnique, Palaiseau, France: Radiation Studies

Josep Calbo, Departament de Fısica, Universitat de Girona (UdG), Girona, Spain: Radiation Studies

Daan Swart: National Institute for Public Health and Environmental Protection, The Netherlands: Ozone lidar measurements of vertical ozone profiles at Lauder

Ulrich Platt, University of Heidelberg, Germany: Development of instruments and techniques, data sharing and interpretation

Martin Dameris & Hella Garny: DLR-Institut für Physik der Atmosphäre, Germany: Collaboration on chemistry-climate modelling

Mario Blumthaler: Medical University of Innsbruck, Austria: Inter-comparisons and sky radiances

Dietrich Häder: University of Erlangen, Germany: Global variability of UV Eldonet instrument network

Günther Seckmeyer: University of Hannover, Germany: Sky imagery and pollution effects

Michiel van Roozendael, Belgium Institute of Space Aeronomy: Maintain UV/Visible trace gas standards and development of new techniques (NDACC)

Martine de Mazière, BIRA, Belgium: Interpretation of FTS measurements and validation of satellite data

Alkis Bais (Thessaloniki, Greece): UNEP

Lars Olof Bjørn, Lund Univ, Sweden: UNEP FAQs

Collaborations with Africa

Piet Aucamp (Private consultant, South Africa): UNEP FAQs

Caradee Guy, Univ Natal: UV dosimeters

Collaborations with Southeast Asia and Japan

Hideaki Nakajima, National Institute for Environmental Studies, Japan: Provision of Improved Limb Atmospheric Spectrometer (ILAS) satellite-based measurements of trace gases

Tetsu Nagai, Meteorological Research Institute of Japan: Aerosol lidar

Osamu Uchino, National Institute of Environmental Studies, Japan: Aerosol lidar

Yoshihiro Kondo: University of Tokyo, Japan: Spectral irradiance & actinic flux in polluted sites, aerosol studies

Collaborations with South America

Francesco Zaratti, Univ San Andreas, La Paz, Bolivia: Dissemination of UVI information

Sergio Cabrera, Univ de Chile, Santiago, Chile: Dissemination of UVI information

Ruben Piacentini, CONICET, Rosario, Argentina: Dissemination of UVI information

Hector Guillen, Soc Photobiology, Arequipa, Peru: Dissemination of UVI information

Susana Diaz, CONECIT, Buenos Aires, Argentina: UVI/WMO

Ozone Research in New Zealand

Of the more than 70 active NDACC measurement sites in the world, only three are equipped with a full complement of standard ozone measuring instruments: ozonesondes, Dobson spectrophotometer, UV/vis spectrometer, lidar, FTIR, microwave radiometer, as well as surface *in situ* observations. New Zealand is home to one of these sites (Lauder): the only one in the Southern Hemisphere.

Long time series measurements are key to identifying trends; the Lauder measurement site hosts several on-going multi-decadal data sets relevant to ozone research, including:

- Stratospheric NO_2 since 1981 (33 years)
- Ozonesondes since 1986 (28 years)
- Dobson Ozone since 1987 (27 years)
- UV Spectrometers since 1989 (25 years)
- Ozone lidar since 1994 (20 years)
- Microwave radiometers since 1994 (20 years)
- TEI *in situ* ozone analyser since 2004 (10 years)

Electrochemical cell ozonesondes have been launched weekly since 1986 at Lauder, New Zealand (45°S, 170°E, 370 meters above sea level), a rural and clean background site representative of Southern mid-latitudes. With this data it is possible to assess the impact of dynamical and chemical changes and climate variability on ozone changes from the surface to the lower stratosphere at Lauder.

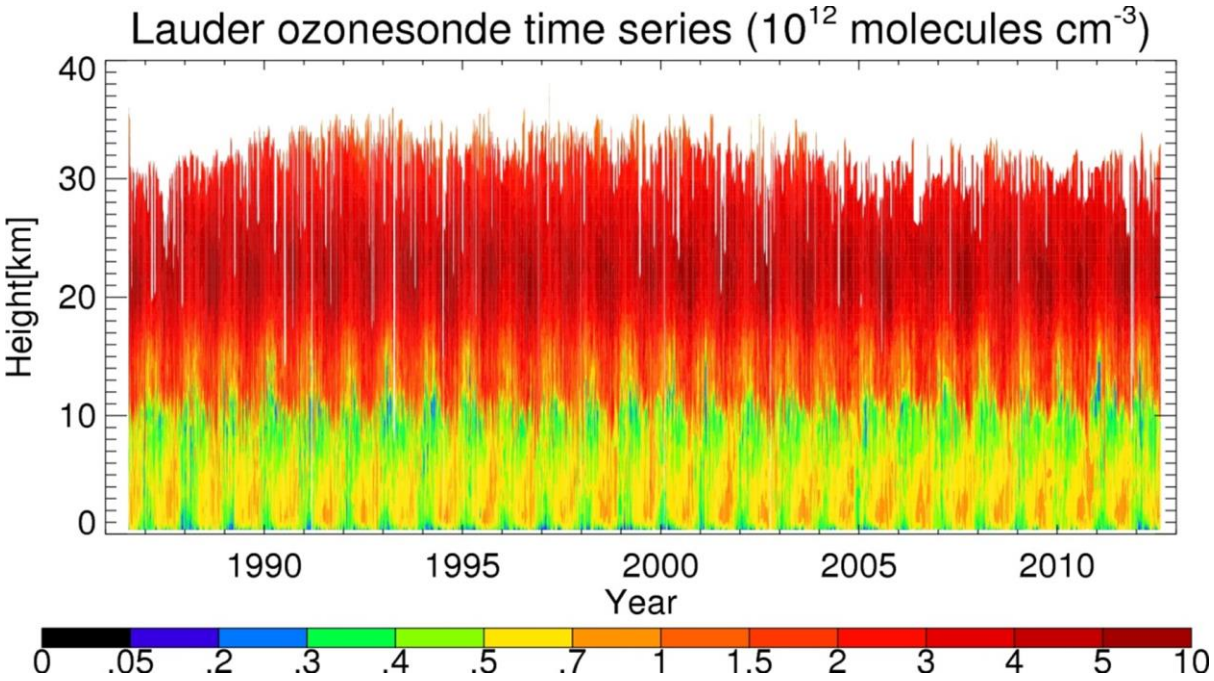

Figure 2: Time series of ozonesondes from Lauder which have been launched weekly since 1986.

The stratospheric NO_2 time series from Lauder is the longest in the world: 1981 – present.

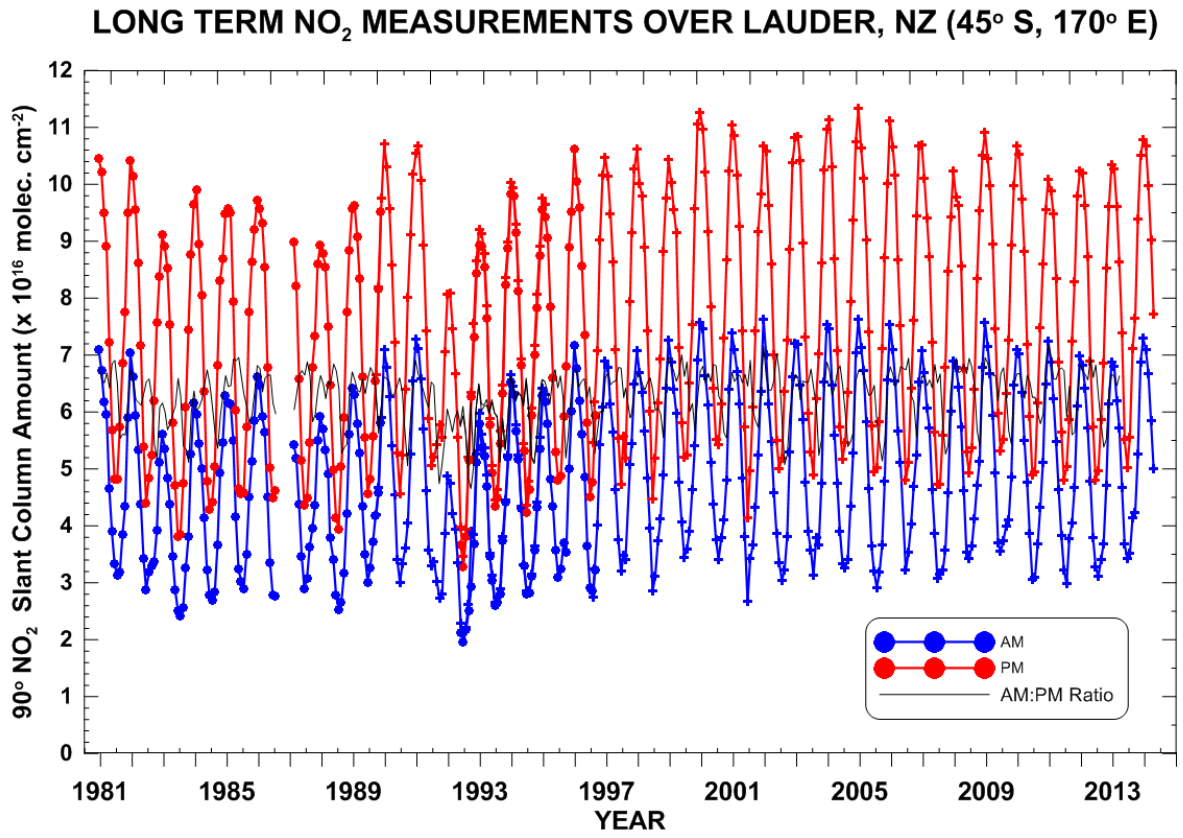

Figure 3: NO2 time series from the UV/Vis spectrometers at Lauder since 1981.

The Dobson spectrophotometer at Lauder has been measuring since 1987 and is one of several NOAA instruments measuring at locations around the world.

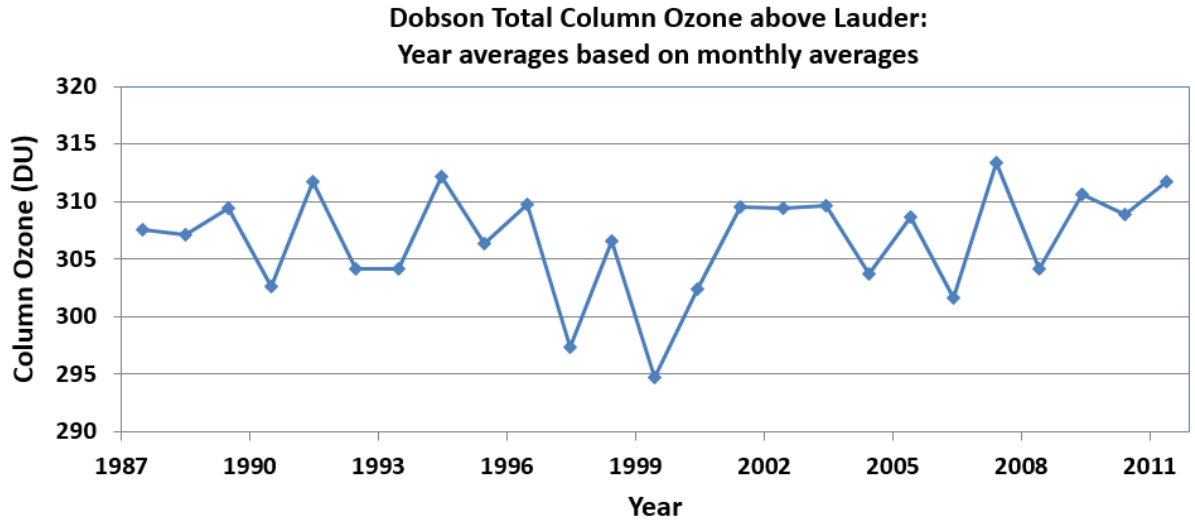

Figure 4: Total column ozone from Dobson spectrophotometer measurements at Lauder. Plotted are the yearly averages based on monthly averages. Note the possible trend reversal beginning from 1999.

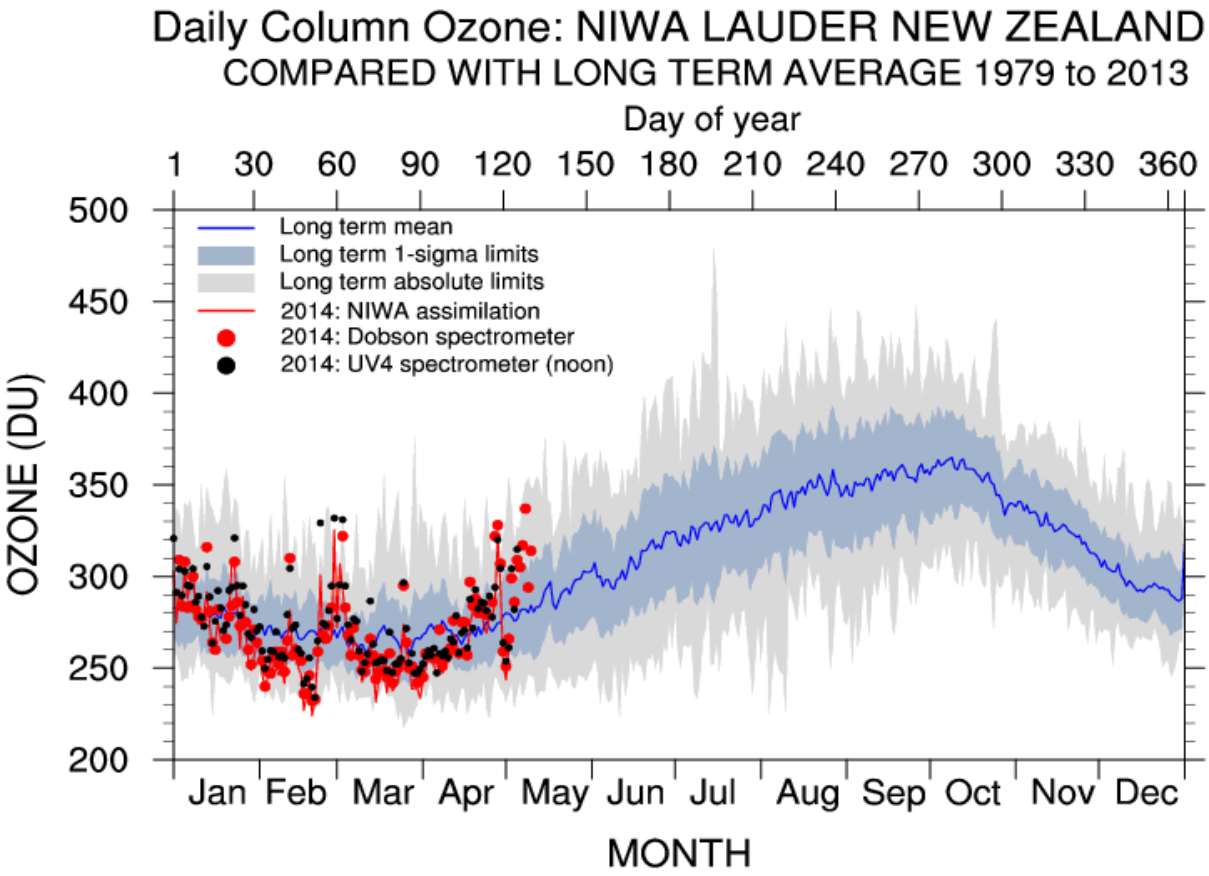

Figure 5: Daily column ozone data from Lauder as compared to the long term average (1979-2013). Shown in the plot are measurements from a Dobson spectrometer, estimates of ozone from the UV4 spectrometer, along with modelled estimates from the NIWA combined total column ozone data base.

Bodeker Scientific has received funding from the New Zealand Antarctic Research Institute to develop a stratospheric ozone module for an interactive simple climate model that can be used to make ensemble projections of the development of the ozone layer through the 21st century that incorporates the effects of changes in CO_2 and ozone depleting substances on ozone, and feedbacks of ozone on the climate system by virtue of its radiative forcing.

Due to funding constraints, maintenance of the Bodeker Scientific global total column ozone database[1] and the vertically resolved ozone database[2] has ceased, as have the analyses from these databases, for example various metrics of Antarctic ozone depletion[3].

[1] http://www.bodekerscientific.com/data/total-column-ozone
[2] http://www.bodekerscientific.com/data/monthly-mean-global-vertically-resolved-ozone
[3] Bodeker, G.E.; Shiona, H. and Eskes, H., Indicators of Antarctic ozone depletion, Atmos. Chem. Phys., 5, 2603-2615, 2005.

Future Plans

- All ozone measuring instrumentation at Lauder and Arrival Heights are fully operational and recording data.
- Ozonesonde launches at Lauder will proceed under the current 1 per week schedule.
- A proposal has been submitted to upgrade the Dobson instrument installed at Arrival Heights. This will involve transportation back to Lauder where it will have automation hardware installed along with a pre- and post-upgrade calibration/validation run with respect to the Lauder Dobson unit.
- An intercomparison study of Lauder ozone instrumentation is underway.

Needs and Recommendations

The following needs and recommendations require attention:

- Particularly in the tropics, there is some disagreement between different datasets, and w.r.t. model results, regarding the trends since 2000 of total column ozone. Detection of ozone recovery in this region would benefit from resolving these discrepancies.
- The budget for carbon tetrachloride remains unbalanced. Further measurements in more locations, close to potential sources, of this important ozone-depleting substance, would be useful.
- The effects of stratospheric change on surface climate change, and the mechanisms involved, need to be better quantified. There is now largely a consensus in the literature that seasonally past ozone depletion has been the dominant driver of climate change in the Southern Hemisphere, and future ozone recovery will remain an important driver of climate change, but large uncertainties remain about the regional impacts of both.
- In particular, the links, if any, between ozone depletion and expanding sea ice around Antarctica remain poorly understood and are generally not captured by general circulation models. This casts doubt on climate projections of the Southern Hemisphere.
- Changes in ozone in the upper troposphere and lower stratosphere, especially in the tropics, need to be better quantified and the effects of changes in ozone in this region of the atmosphere on the temperature structure of the atmosphere need to be better quantified.
- An ongoing debate about 'optimal' levels of UV exposure indicates that further research on vitamin D production and its health effects would be useful.
- A better quantification of natural sources of bromine in the troposphere is needed. Particularly, a possible intensification of the aquaculture of kelp, either for food production and carbon capture, would cause a potentially significant increase in the production of bromocarbons, which can affect the stratospheric ozone layer. This risk needs to be understood.

- Continuing support for long-term, high quality measurement sites.

Relevant scientific publications since 2011. NZ authors are in bold:

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