New Zealand National Report
for the 12th WMO/UNEP Ozone Research Managers Meeting
Geneva, April 2024

Introduction

In New Zealand, ozone- and UV-related research is undertaken by the National Institute of Water & Atmospheric Research (NIWA), the University of Canterbury, the University of Otago, and Bodeker Scientific. Many relevant observations are taken at the Lauder Atmospheric Research Station in Central Otago. Lauder station, located at the Southern mid-latitudes (45°S, 170°E, 370 m.a.s.l.) is a rural and clean background-level site. It is a Global station of the WMO's Global Atmosphere Watch Programme (GAW) and is a member of several international networks including the Network for the Detection of Atmospheric Composition Change (NDACC), Baseline Surface Radiation Network (BSRN), Total Carbon Column Observing Network (TCCON), and GCOS Reference Upper Air Network (GRUAN).

Ozone and several parameters related to ozone depletion are measured using a range of techniques including Dobson spectrophotometry, UV-visible spectroscopy, infrared spectroscopy, microwave radiometry, electrochemical ozonesondes flown on balloons, ozone and aerosol lidars, *in situ* sampling, and frost-point hygrometers. Solar UV radiation is measured at several sites across New Zealand. There are also measurement activities outside of New Zealand, such as in Antarctica (Scott Base and Arrival Heights, 78°S, 167°E, 184 m.a.s.l.) and some sites in the Pacific Islands. Due to its location in the Southern Hemisphere and proximity to Antarctica, New Zealand is particularly interested in the effects of stratospheric ozone depletion. The Deep South National Science Challenge, a 10-year research programme (ending in 2024), is aimed at improving our understanding of how changes in the Antarctic region affected New Zealand; the effect of ozone depletion and recovery on climate is part of this programme.

Since 2020, there have been two unprecedented events in our region that have been of great scientific interest across the atmospheric chemistry, observation, and modelling communities: the massive pyrocumulonimbus smoke clouds resulting from the Australian New Year bushfires of early 2020; and the eruption of the Hunga Tonga–Hunga Haʻapai (HT-HH) underwater volcano. Both events radically affected stratospheric chemistry: the fires through increased carbonaceous aerosol and subsequent heterogeneous chemistry (the bushfire smoke did not behave like the typical sulfate aerosols from volcanoes); and the water and materials ejected from the underwater volcano substantially increased water vapour in the upper stratosphere, a region which is usually quite dry. That water enabled new chemical pathways typically not possible at those temperatures. Observations from Lauder and Arrival Heights are key measurements in several Australian bushfire and HT-HH studies.

1. OBSERVATIONAL ACTIVITIES

Ozone research in New Zealand

Of the more than 70 active NDACC measurement sites in the world, only Lauder is equipped with a full complement of the five standard ground-based ozone profile measuring techniques: ozonesondes, Dobson Umkehr, lidar, FTS, and microwave radiometry. Total column ozone is also measured at Lauder using UV/vis spectrometers and surface *in situ* observations are made using UV photometers. Other sites across New Zealand also have active surface ozone measurement programmes, including city council sites in Auckland and Christchurch as part of their urban air quality instrumentation.

High quality, 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. New Zealand's Arrival Heights Research facility in Antarctica hosts a similar suite of instruments that also measure ozone and compounds relevant for ozone production and destruction.

1.1 Column measurements of ozone and other gases/variables relevant to ozone loss

Lauder atmospheric research station:

- UV/vis stratospheric NO_2 since 1981
- Dobson total column ozone since 1987
- UV spectrometers since 1989
- FTS column ozone and other ODS measurements since 1990
- TEI *in situ* ozone analyser since 2004

Arrival Heights, Antarctica:

- Dobson total column ozone since 1988
- UV/vis stratospheric NO_2 since 1991
- FTS column ozone and other ODS measurements since 1996
- TEI *in situ* ozone analyser since 2003

1.2 Profile measurements of ozone and other gases/variables relevant to ozone loss

Lauder atmospheric research station:

- Ozonesondes, weekly launches since 1986 which included radiosonde measurements of pressure, temperature and humidity
- Dobson Umkehr since 1987
- FTS (ozone and other ODSs) since 1990
- Ozone lidar since 1994
- Microwave radiometer profiling since 1994
- NOAA frost-point hygrometers since 2004

Arrival Heights, Antarctica:

- Microwave radiometer profiling (ClO) since 1996
- FTS, ozone profile measurements since 1996

1.3 UV measurements

Activities from NIWA's UV radiation programme are summarized at https://www.niwa.co.nz/our-services/online-services/uv-ozone

Spectral:

NIWA maintains spectral measurements at Lauder, as well as at Boulder Colorado and Mauna Loa Observatory Hawaii, though the latter have been disrupted by volcanic activity there. Measurements at Alice Springs and Melbourne, Australia are in abeyance, with both instruments requiring repair but no funds forthcoming. Data from these NDACC sites are archived at the NDACC database, and spectral data are archived from in the WOUDC database. Historical spectral data are also available from Tokyo, Japan, and Darwin, Australia.

Broadband:

NIWA maintains 5 Yankee UVB-1 pyranometers (i.e., new generation Robertson Berger "RB-type" meters) in New Zealand. Data from these are archived in the NIWA climate database and are used in regular reports by the New Zealand Ministry for the Environment (https://environment.govt.nz/publications/our-atmosphere-and-climate-2023/state-of-our-atmosphere-and-climate/). NIWA also assists Callaghan Innovation to process and archive data from their UVB-1 meters at other sites in New Zealand.

Complementary Measurements:
In support of NIWA's UV measurement programme, the following are also available at Lauder:

- TCCON (Total Carbon Column Observation Network)
- BSRN radiation suite (direct, diffuse, and global short-wave radiation)
- Aerosol optical depth at several wavelengths, and from lidar
- All sky cameras
- Direct beam spectral irradiances (285-600 nm)
- Actinic flux measurements (JNO_2)
- Sunshine recorders
- USDA radiation suite
- Meteorological data
- Trace gas measurements

Additionally, NIWA has been closely involved with the development and use of personal UV dosimeters.

A new version of the Scienterra UV Dosimeter measures concurrent erythemal UV, UVA, red, green, blue, and broadband white/IR wavebands, covering 280-1000 nm. The green channel matches the photopic eye response, and the blue channel matches the melatonin suppression action spectrum. Additional functions include orientation, pedometry and GGIR-type motion analysis. Data are provided over Bluetooth to a smartphone app, with daily uploads to a cloud-based database. More information can be found at: http://scienterra.com/. The badges were deployed by PMOD/WRC for the UVC-III intercomparison and did well for its small size and low power (https://library.wmo.int/viewer/68642/download?file=GAW-284-report_en.pdf&type=pdf&navigator=1, pp192-195). Scienterra is also participating in MeLiDos, a consortium to recommend how personal dosimeters and light loggers should be qualified and used to study melanopsin (blue light exposure) and also UV. More information can be found at: http://scienterra.com/

1.4 Calibration activities

- NIWA UV spectrometers are used to cross calibrate other spectrometers in Australasia.
- Broadband meters are cross calibrated against spectroradiometers at Lauder.
- Lauder Dobson (D072) and Arrival Heights Dobson, both participated in an NDACC intercomparison relative to the regional and global standard Dobsons, in Melbourne, December 2022.

2. RESULTS FROM OBSERVATIONS AND ANALYSIS

Results are disseminated through numerous publications, conference presentations, seminars, and web pages. See section 4 below.

3. THEORY, MODELLING, AND OTHER OZONE RELATED RESEARCH

New Zealand efforts in theory and modelling, as with the measurements, are disseminated through research papers, UNEP EEAP Reports, and WMO Ozone Assessment Reports. For example:
UNEP: http://ozone.unep.org/en/assessment-panels/environmental-effects-assessment-panel
WMO: http://ozone.unep.org/en/assessment-panels/scientific-assessment-panel

IGAC/SPARC Chemistry-Climate Model Initiative (CCMI): New Zealand has contributed to a new round of chemistry climate model evaluation, CCMI2022. The aim of CCMI is to improve our understanding of these complex systems and help inform ozone, climate, and air quality assessments. The CCMI2022 simulations will be used in the 2026 WMO Scientific Assessment of Ozone Depletion report, and have begun to inform scientific publications, e.g. Charlesworth et al. (2023). In addition, New Zealand has helped author the 2022 WMO Scientific Assessment of Ozone Depletion.

At NIWA, using a long-term homogenised ozonesonde data set with chemistry-climate model simulations, a study was carried out to quantify the role of GHGs, e.g. CO_2, CH_4, N_2O, and other ODSs, in driving the long-term ozone trend over Lauder, New Zealand. The results clearly show that CO2-driven dynamical changes play an important role in driving the lower stratospheric ozone trends in this region.

The University of Otago was a key participant in the development of the first solar forcing proxy for energetic particle precipitation (EPP) to be used in chemistry-climate models. EPP influences polar mesospheric and upper stratospheric ozone variability, particularly during winter and spring seasons, with demonstrated links to regional climate variability. This proxy is used in the CMIP6 (Coupled Model Intercomparison Project Phase 6) global simulations. The CMIP6 EPP proxy is available from: https://solarisheppa.geomar.de/cmip6.

The University of Otago is a major contributor to global climate modelling efforts. These climate model simulations aim to improve our understanding of solar influence (via EPP) on polar ozone, and to investigate the physical mechanisms driving predicted and detected surface level regional climate responses that arise from changes in ozone. This research is driven by the global need to improve our understanding of, and capability to simulate, background regional climate variability driven by solar activity.

The University of Canterbury is undertaking research on the effects of ozone recovery on surface climate through the MBIE Endeavour programme 'Extreme Events and the Emergence of Climate Change'. Research in this programme has examined how the Southern Hemisphere westerly jet responds to greenhouse gas emissions in CMIP6 models and proposed a new metric for quantifying ozone loss and recovery – that of signal to noise.

The University of Canterbury is researching the impact of rocket launch emissions on stratospheric ozone. They have compiled an inventory of emissions from four major rocket fuel types and are modelling impacts on the ozone layer.

Another example of this work is the Deep South-funded research whereby scientists at Bodeker Scientific have developed updated versions of the long-term homogeneous databases of (1) total column ozone and (2) vertically resolved monthly mean zonal mean ozone:

1. Total Column Ozone: Version 3.5.1 of the NIWA-BS total column ozone (TCO) database is now available. The generation of the database was funded through a project by the New Zealand Deep South National Science Challenge. This version of the database extends version 3.4 to the end of

2019. As with previous versions, the database is constructed by combining measurements from several different satellite-based instruments and extends from 1 November 1978 to 31 December 2019. Offsets and drifts between the different data sets are resolved through comparisons with the Dobson and Brewer ground-based instruments and through inter-satellite instrument comparisons.

2. Vertically resolved ozone database: The latest version of the Bodeker Scientific Vertically Resolved Ozone Database (BSVerticalOzone) is available on the Bodeker Scientific website (https://www.bodekerscientific.com/data/monthly-mean-global-vertically-resolved-ozone). This database is constructed by combining measurements from several satellite-based instruments and ozonesondes and extends from 1979 to 2016. Monthly mean zonal mean ozone concentrations in mixing ratio and number density are provided in 5° latitude bins, spanning 70 altitude levels (1 to 70 km), or 70 pressure levels that are approximately 1 km apart (878.4 to 0.046 hPa). A gap filling technique is used to generate different data sets or 'Tiers'. The different Tier 1.X data sets can be used for comparisons with chemistry–climate model (CCM) simulations that do not exhibit the same unforced variability as reality (unless they are nudged towards reanalyses).

4. DISSEMINATION OF RESULTS

4.1 Data reporting

See above. NIWA UV data are archived at:

NDACC: http://www.ndsc.ncep.noaa.gov/data/ (spectral summaries)
WOUDC: http://woudc.org/
NIWA: https://cliflo.niwa.co.nz/ (broad band)
Surface in situ ozone: https://www.esrl.noaa.gov/gmd/ozwv/surfoz/data.html

Scientific papers, etc. (see below)

NDACC, WOUDC: Dobson total column ozone and Umkehr profiles
NDACC, WOUDC: Microwave radiometer profiles
NDACC, WOUDC, GRUAN: Ozonesonde profiles
NDACC, GRUAN: Frost-point hygrometer water vapour profiles
NDACC: FTS ozone & ODSs, total column and profiles
NDACC: Ozone lidar profiles

4.2 Information to the public

Information to the public is provided by:

- Data archived at NDACC, WOUDC, GRUAN, etc., are all publicly accessible.
- NIWA provides information about UV forecasts, maps of ozone and UV, time series of ozone on their publicly available web pages.
- UV Index displays are installed in some public places, together with behavioural advice.
- Smartphone apps that show the UV variation during the course of the day and include cloud effects and corresponding behavioural advice. Some apps include the daily exposure times needed for vitamin D sufficiency (as functions of specified skin type and clothing attire). https://niwa.co.nz/our-services/online-services/uv-ozone/uvi-smartphone-apps
    - The uv2Day app (NZ – Australia – South Pacific – Antarctica only)
    - The GlobalUV app (Global, but with daily noon cloud cover only)

    - The UVNZ app (NZ only)
- Interaction with New Zealand health providers regarding both positive and negative effects of UV. For example:
    - https://www.health.govt.nz/system/files/documents/publications/vitamind-sun-exposure.pdf
    - http://www.sunsmartschools.co.nz/PS_RisksBenefits_SunExposureSept08.pdf.

4.3 Relevant scientific papers

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5. PROJECTS, COLLABORATION, TWINNING AND CAPACITY BUILDING

National Projects

Ozone and related research in New Zealand are undertaken primarily through the Understanding Atmospheric Composition and Change programme (NIWA), which includes various measurement activities of ozone and associated compounds, primarily at Lauder, New Zealand, and Arrival Heights, Antarctica, measurement of physical variables such as UV, as well as global chemistry-climate modelling at NIWA and New Zealand's Universities. 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.

MBIE Endeavour fund Smart Ideas project “Space-ready radiometers for climate monitoring: using light to detect thermal radiation” lead by University of Otago is developing a novel type of ozone monitor suitable for a cubesat platform.

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 compounds to NDACC, taken at its primary locations at Lauder, New Zealand, and Arrival Heights, Antarctica, and also UV/Vis measurements of column NO_2 from Macquarie Island, Australia, taken in collaboration with the Australian Bureau of Meteorology.

- Tropospheric Ozone Assessment Report (TOAR & TOAR-II), data submission and participation.

- SPARC LOTUS activity (Long-term Ozone Trends and Uncertainties in the Stratosphere), data submission and participation.

- The Harmonization and Evaluation of Ground Based Instruments for Free Tropospheric Ozone Measurements (HEGIFTOM) Focus Working Group.

- CAMS project (Copernicus Atmosphere Monitoring Service), rapid-delivery data submissions.

- SPARC activity: contributions to and co-chairing sections of a special report on Hunga Tonga impacts.

- IGAC/SPARC Chemistry-Climate Model Initiative Phase 2 (CCMI-2).

- GRUAN (GCOS Reference Upper Air Network): Measurements of ozone, water vapour and meteorological parameters using ozonesondes and high-quality radiosondes are made at Lauder, a site hosting a GRUAN-certified measurement programme. Radiosonde measurements at Invercargill are submitted to GRUAN as a collaboration between NIWA and the New Zealand MetService. In support of GRUAN activities, NIWA has introduced additional quality checks to radiosonde preparations and has installed a GPS/GNSS receiver used for measuring total water vapour column abundance.

- BSRN (Baseline Surface Radiation Network): Measurements of global, diffuse, and direct radiation at Lauder, to the standards of BSRN, have been made continuously at Lauder since 1999, with the results available from the BSRN archive used in satellite validation and studies of global radiative energy balance. They also support the understanding of UV measurements at Lauder and other NDACC sites.

- SAGE-III-ISS Validation: An ongoing validation effort is underway at Lauder with several balloon payloads launched annually in coordination with ISS overpasses. These payloads included ozonesondes, frost-point hygrometers, and more recently a POPS aerosol measuring instrument.

- SOLARIS-HEPPA - Solar influences for SPARC (Stratosphere-troposphere processed and their role in climate): University of Otago is a key participant in the development of solar forcing parameters used by the co-called high-top models with interactive ozone chemistry CMIP6 simulations.

- A continuous record of stratospheric aerosol profiles over Lauder, started in November 1992, continues thanks to support from MRI and NIES in Japan. The lidar was upgraded in 2009 for dual-wavelength and depolarisation in daytime to support Total Carbon Column Observing Network (TCCON) measurements of GHG over Lauder by near-infrared.

- CMIP7: University of Otago is participating in forming the solar forcing dataset and associated ozone forcing dataset for the use of CMIP7 model simulations.

- Lauder & Arrival Heights MAXDOAS data are submitted to the BIRA-led FRM4DOAS central processing of MAXDOAS spectra to generate column ozone and tropospheric NO_2 profiles.

National collaborators

NIWA

Richard Querel, Lauder: Ozonesondes, ozone lidar, Dobson; GRUAN

Ben Liley, Lauder: UV, clouds, aerosols, aerosol lidar

Richard McKenzie (Emeritus), Lauder: UV

Olaf Morgenstern, Wellington: Chemistry-climate modelling

Guang Zeng, Wellington: Chemistry-climate modelling

Dan Smale, Lauder: *In situ* ozone (TEI) measurements, FTS column and profile measurements

Penny Smale, Lauder: Ozonesondes, Dobson, TEI

Michael Kotkamp, Lauder: Ozone microwave radiometer, UV instrumentation

Alex Geddes, Lauder: UV measurements, ozonesonde processing

Sylvia Nichol, Wellington: Dobson measurements

Hisako Shiona, Christchurch: Dobson measurements, ozonesonde processing

New Zealand institutions

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

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

Annika Seppälä, University of Otago: Space weather (EPP) effects on the stratosphere and ozone. Chemistry-climate modelling.

Martin Allen, University of Canterbury: UV dosimetry

Barbara Hegan, Cancer Society: UV Public health advisory

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

Laura Revell, University of Canterbury: Chemistry-climate modelling, stratospheric ozone chemistry.

Michele Bannister, University of Canterbury: rocket launch emissions

Dave Frame, Victoria University of Wellington: Climate dynamics

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

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

Martin Allen, University of Canterbury: Dosimeters

Zim Sherman, Scienterra, Timaru: Dosimeters

Health agencies including HPA and Cancer Society, Melnet, NZ Dermatological Association

NZ Meteorological Service (provision of UVI forecasts)

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

Stephen Wilson, University of Wollongong: MAXDOAS measurements

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

Matt Tully, Bureau of Meteorology: Ozonesondes, Dobson intercomparison

Steve Rhodes, Bureau of Meteorology: Dobson intercomparison, MAXDOAS

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

Michael Kimlin (QUT): UV Workshop

Robyn Schofield, Univ Melbourne: MAXDOAS measurements

Sharon Robinson, University of Wollongong, Australia: ozone, UV, biology

Rachel Neale, UNEP, UV & Health, QIMR Berghofer Medical Research Institute, Brisbane

USA and Canada collaborations

NOAA

Elizabeth Asher, GMD: PI frost point hygrometer flights at Lauder

Audra McClure, GMD: *In situ* ozone measurements

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

Irina Petropavlovskikh, GMD: Dobson total-column ozone measurements

Glen McConville, CIRES, GMD: Dobson

Koji Miyagawa, NOAA, GMD: Dobson

GMD = Global Monitoring Division (was CMDL); CSD = Chemical Sciences Division (was aeronomy laboratory); CUCF = Colorado Ultraviolet Calibration Facility; CIRES (Cooperative Institute for Research in Environmental Sciences)

NASA

Anne Thompson, GSFC: Ozonesondes

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.

Jeannette Wild, NDACC: NDACC data archival, meta data

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

Susan Strahan, GSFC: Modelling activities

Thierry Leblanc, JPL: Ozone lidar

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

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

Rachele Ossola, Colorado State University: ozone recovery and environmental effects

USDA = United States Department of Agriculture

Other USA and Canada

Daniel R. Marsh, NCAR (also University of Leeds, UK): Chemistry-Climate modelling

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

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

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

Vitali Fioletov, Environment Canada: UVI

Jim Hannigan, NCAR: FTS measurements.

NCAR = National Center for Atmospheric Research

Collaborations with Europe

Christoph Zellweger. WCC-Empa, Empa Dübendorf, Switzerland. In situ ozone calibration

Wolfgang Steinbrecht, Germany. Ozone lidar

Monika Szelag (previously Andersson), Niilo Kalakoski, Johanna Tamminen, Finnish Meteorological Institute: Chemistry-Climate modelling, satellite observations of stratospheric composition.

Pekka T. Verronen, Esa Turunen, Jia Jia, Sodankylä Geophysical Observatory: Ion-Chemistry modelling, mesospheric ozone observations.

Mark A. Clilverd, David A. Newnham, British Antarctic Survey: Radiometer observations of polar mesosphere composition, development of solar forcing proxies for climate models.

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

John Pyle, Alex Archibald, Luke Abraham, University of Cambridge: Chemistry-climate modelling

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

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

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

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

Michel 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

Corinne Vigouroux, BIRA, Belgium: FTS, MAXDOAS

Daan Hubert, BIRA, Belgium: LOTUS, satellite ozone trends

Emmanuel Mahieu, Univ. Liege, Belgium: FTS measurements

Herman Smit, Research Centre Juelich GmbH, Germany: Ozonesondes

Alkis Bais (Thessaloniki, Greece): UNEP

Lars Olof Bjørn, (emeritus) Lund Univ, Sweden: UNEP FAQs

FMI, Finland. Data for UVI Apps (uv2Day and GlobalUV)

Thomas Peter, Andrea Stenke, Will Ball (ETH Zurich) and Eugene Rozanov and Timofei Sukhodolov (ETH/PMOD), Switzerland: Collaboration on chemistry-climate modelling.

Collaborations with Africa

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

Caradee Wright, South African Medical Research Council: UV dosimeters

Collaborations with Southeast Asia and Japan

Tomohiro Nagai, Tetsu Sakai, Meteorological Research Institute of Japan: Aerosol lidar

Isamu Morino, Osamu Uchino, Yoshitaka Jin, National Institute of Environmental Studies, Japan: Aerosol lidar & Skyradiometer

Makoto Koike, Yutaka 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

Roy Mackenzie, Universidad de Magallanes, Puerto Williams, Chile: ozone recovery and environmental effects

6. IMPLEMENTATION OF THE RECOMMENDATIONS OF THE 11th OZONE RESEARCH MANAGERS MEETING

In line with the recommendations from the 11th ORM, New Zealand is continuing to fund high-quality trace gas measurements through the Strategic Science Investment Fund (SSIF) funding provided to NIWA. Relatedly, an ongoing task within NIWA is upgrading instruments and logging systems to ensure continuity of these multi-decade time-series datasets.

In response to 'Aviation, rockets, and climate intervention,' the University of Canterbury is researching the impact of rocket launch emissions on stratospheric ozone. They have compiled an inventory of emissions from four major rocket fuel types and are modelling impacts on the ozone layer.

7. FUTURE PLANS

- Maintain and continue operation of all ozone and ODS measuring instrumentation at Lauder, Baring Head, and Arrival Heights.
- Participate in network-wide instrument intercomparison and calibration campaigns.
- Complete the redevelopment of the Lauder stratospheric ozone lidar (LauSOL).
- Continue weekly ozonesonde launches at Lauder.
- Multi-instrument comparisons and trend analysis of the ozone measurements from Lauder are being performed.
- Update NIWA UV spectrometer systems at Lauder (and abroad), including the conversion of legacy control and processing software and all custom hardware as required.
- Producing chemistry-climate model projections of stratospheric ozone in response to changing GHG and ODS concentrations; understanding how stratospheric chemistry influences surface climate and the emergence of climate change in the Southern Hemisphere.

8. NEEDS AND RECOMMENDATIONS

- Continue support for long-term high-quality ozone measurements in New Zealand.
- Continue ground-based validation of satellite measurements.
- Continue satellite measurements of atmospheric trace gases during polar night conditions to better quantify variability at high and mid-latitude regions.
- Continue support for chemistry-climate modelling in New Zealand.
- Changes in ozone in the UTLS and its effect on atmospheric temperature need to be better quantified.
- The effects of stratospheric change on surface climate change, and the mechanisms involved, need to be better quantified. There is now a scientific 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.
- An ongoing debate about optimal levels of UV exposure indicates that further research on vitamin D production and its health effects would be useful.