Solar radiation, health, and energy

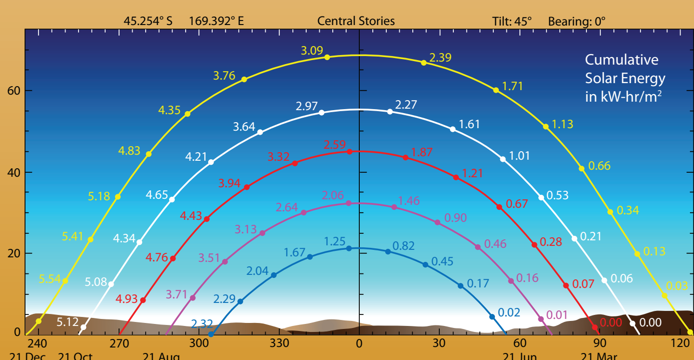
Because of the success of the Montreal Protocol, increases in UV have been relatively small, and the worst may now be behind us. However, we have intense UV in summer. Our peak UVI values are 40 percent more than corresponding northern latitudes – which contributes to our high rate of melanoma. We also have weak UV in winter – which contributes to low levels of vitamin D.

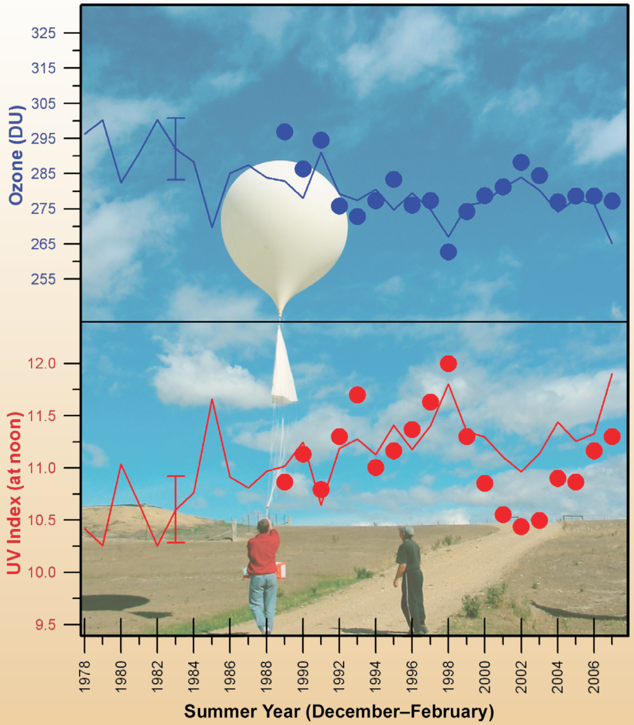
As well as providing daily forecasts of UVI, we work with health agencies to give advice on the risks and benefits of UV radiation. We have developed UVI displays for public use, and have used personal UV dosimeter badges to relate UV exposure to health status.

UV Index display showing UVI at the annual Goldrush multisport event Alexandra, Central Otago.

Future changes in cloud and aerosols will impact on solar radiation received at the surface. Changes in UV will impact on human health and the environment; while changes in visible and infra-red radiation will impact on availability of solar energy.

We've also developed a tool to estimate the solar energy available throughout the day and year at any specified site in New Zealand. Any solar panel orientation can be specified. The calculation includes effects of clouds and horizon obscurations. An example of solar energy availability is shown below for the Central Stories museum site in Alexandra. The lines labelled with cumulative energy show the compass bearing (x-axis) and elevation (y-axis) of the sun on five days of the year. The labelled points are at 1 hour intervals.





Long term changes in peak summertime ozone (upper panel) and UV Index (lower panel) at Lauder. The lines show ozone measured from satellite, and corresponding clear-sky UVI calculated from those ozone amounts. The circles show ozone and UVI measured directly by NIWA UV spectrometers.

Group visits to NIWA Lauder are welcome by appointment.
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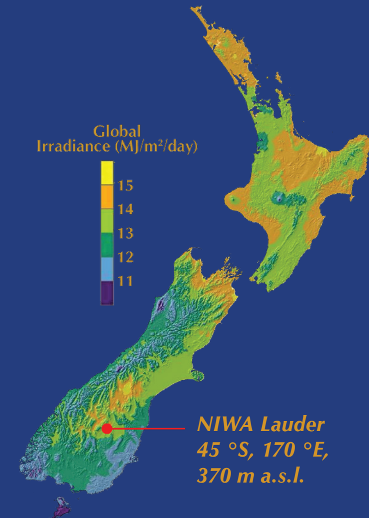
NIWA
Taihoro Nukurangi

Atmospheric Research at NIWA Lauder

History



Situated 35 kilometres from Alexandra on SH 85, Lauder was once a thriving village servicing the main rail connection between Dunedin and Central Otago. But when the last railcar passed through in 1976, the village – like many others in New Zealand – fell into decline. Although it has seen some resurgence in recent years with the increasing popularity of the Otago Central Rail Trail, many New Zealanders are unaware of Lauder's existence – or its importance the home to a world class atmospheric research centre. Tucked around the corner a couple of kilometres further up the road an inconspicuous sign points to NIWA's Atmospheric Research Station.

Despite its isolation, our research centre is well known throughout the international world of atmospheric research. Indeed Lauder's isolation, along with its clear skies, is what led the former government Department of Scientific and Industrial Research to set up a research laboratory there in the early 1960s. The main job of its scientists was to observe aurora – the ghostly lights emanating from 100-400 kilometres above the Earth's surface, which occur when particles from the Sun interact with the air molecules.

But, by the late 1970s, a more immediate problem was emerging. The ozone layer, which protects us from excess UV radiation, was under threat from man-made gases containing chlorine – from chlorofluorocarbons, bromine (from halons), and from nitrogen oxides. As a result Lauder research shifted its focus to investigating the causes and effects of ozone depletion in the stratosphere 15–50 kilometres above the Earth's surface. Since then our research focus has shifted again to a lower region of the atmosphere, the troposphere (0–15 kilometres), to answer questions about climate change, and the interactions between global warming and ozone depletion. We've also developed computer models at Lauder to project future changes in atmospheric composition, and how that might respond to international environmental policy. We also investigate the health effects of UV radiation (both positive and negative).

Our Team and Our Research Centre

We have approximately 20 staff working at our Lauder research centre. Nationally, NIWA employs more than 750 staff – including oceanographers, hydrologists, fisheries scientists, and atmospheric researchers. Although most Lauder staff members commute daily from Alexandra, some live in on-site housing which also caters for a continuous flow of visiting researchers who come to use our facilities.

The laboratory is located in the broad Manuherikea river valley - flanked by the Dunstan Range and Blackstone Hill. The air is among the cleanest in the world and the climate is extreme by New Zealand standards: hot in summer, cold in winter, and dry all year. It is also quite windy, especially in spring and autumn. The most settled period of the year is late summer/early autumn. There are occasional snow falls in winter, but snow rarely lies for more than a few days. An automated weather station is in operation at the site (http://cliflo.niwa.co.nz/).

Lauder climate statistics

Mean pressure	970 hPa
Mean rainfall	450 mm
Mean wet days (>1 mm)	70
Mean temperature	9.7 °C
Mean of max temp	16 °C
Mean of Min temp	3.5 °C
Absolute max temp (27 Jan 2006)	34.3 °C
Absolute min temp (3 July 1995)	-19.7 °C
Mean ground frost days	145
Mean daily wind run	300 km
Max wind gust	39 m s-1
Mean relative humidity (9 am)	75%
Mean column ozone	310 DU
Mean solar radiation	13.3 MJ m-2

Lauder is also a ground receiving-station for high resolution satellite meteorological and oceanographic imagery. The incoming data are transferred to other NIWA sites via a high-speed fibre-optic link that also connects the computers at Lauder to the internet.

Our Work

Atmospheric measurements

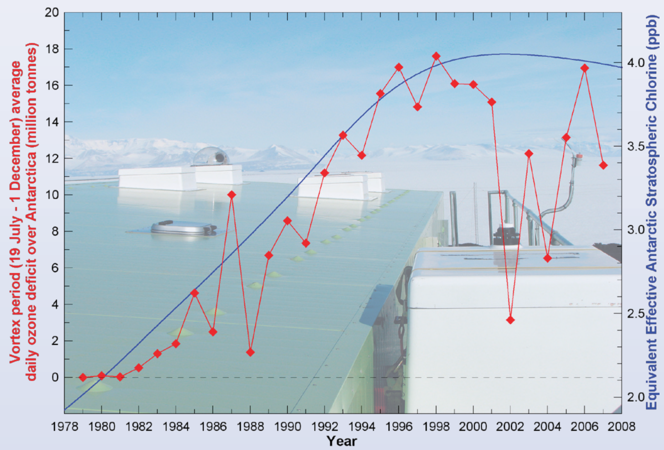
Lauder is one of five global charter sites in the international Network for the Detection of Atmospheric Composition Change (NDACC). Consequently, it has some of the best instruments in the world for atmospheric research. Several of the state-of-the-art instruments are operated in collaboration with overseas partners.

Most of the measurements use absorptions of short wavelength solar radiation, or longer wavelength radiation emitted by the Earth's atmosphere. The most notable exceptions to this are two complementary methods to measure the vertical profile of ozone. Every week, balloons are launched carrying chemical 'in-situ' sensors to altitudes of around 35 kilometres before descending back to the ground. These are complemented by a ground-based LIDAR (Light Detection And Ranging) instrument, which works like RADAR, but instead of using radio waves, it emits beams of pulsed laser-light vertically to altitudes of around 100 kilometres. A small fraction of the light is backscattered by air, and is collected by a telescope. The concentrations of ozone (and also aerosols) can be deduced as functions of altitude from the tiny time-delay between sending the output beam and receiving the scattered beam. We also take measurements of greenhouse gases and solar radiation to international standards at Lauder.

The measurements we provide to the NDACC help the international atmospheric research community to:

(1) monitor long-term changes in atmospheric composition and radiation
(2) validate and calibrate satellite sensors in this data-sparse region of the globe
(3) better understand the causes and effects of ozone depletion, as well as learning more about the causes and effects of climate change, and interactions between global warming and ozone depletion.

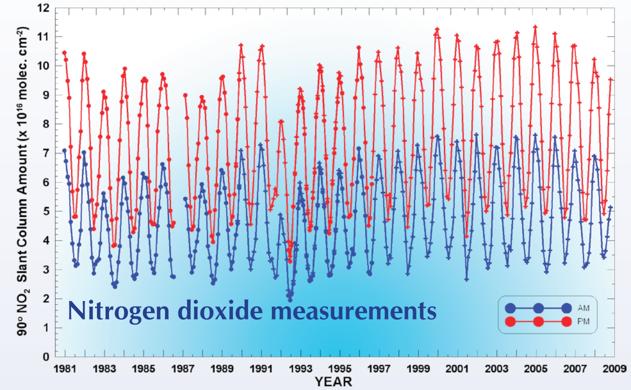
Our scientists at Lauder publish their results widely in scientific literature, conference presentations, web pages (http://www.niwa.co.nz/services/free/uvozone), public lectures, and press releases. They are also actively involved in international assessments of ozone depletion, its environmental impacts, and climate change.



Time series showing the relationship between the severity of the Antarctic ozone 'hole' (in millions of ton ozone lost) since satellite measurements of ozone began and the increasing concentration of ozone-depleting chemicals (equivalent chlorine, in parts per billion).

Atmospheric measurements in Antarctica are also made by our NIWA researchers based at Lauder. These measurements have contributed significantly to our understanding of the causes of the springtime Antarctic 'ozone hole', and its impacts on New Zealand. The severity of the ozone hole increased markedly over the 1980s and 1990s, but has stabilized and shown only erratic variations since. Because approximately half of the decreases in ozone over New Zealand are attributable to Antarctic ozone depletion, the ozone decreases and UV increases that took place over the latter decades of the last century have also ceased. In recent summers peak summertime UV intensities have been similar to those before ozone depletion began.

Our research at Lauder also contributes to the ongoing success of the Montreal Protocol to protect the ozone layer. The production of chemicals that lead to ozone-depleting has reduced greatly, and the stratospheric concentrations of ozone-destroying gases are also decreasing. Consequently, ozone is on its slow path towards recovery, though because of the long lifetime of the harmful gases, a full recovery is not expected until the middle of the 21st century.



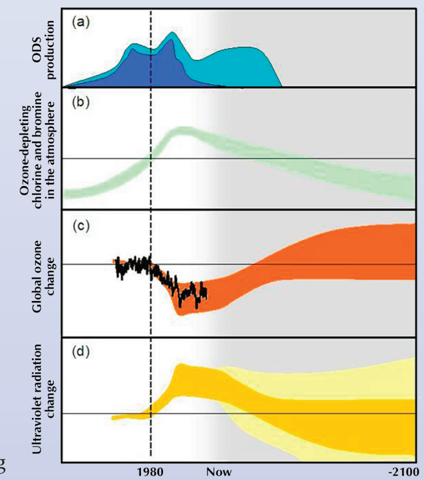
The times series of nitrogen dioxide (NO_2) at Lauder (measured at sunrise and sunset) is the longest in existence.

At Lauder we have the longest time series of NO_2 in the world. It provides robust tests of atmospheric models, and has helped us understand the causes of ozone depletion. To better quantify how ozone is expected to change over the coming decades, we use complex chemistry climate models at Lauder to make projections of future changes in ozone.

Simulations we have run show that increases in greenhouse gases, which cool the stratosphere, will speed the recovery of the ozone layer outside of the polar regions. However, over Antarctica, where lower stratospheric temperatures enhance ozone depletion, increases in greenhouse gases in the atmosphere will delay the recovery of the Antarctic ozone hole by about two decades.

Long term changes in ozone depleting substances, ozone and UV

Unlike other developed countries, New Zealand's emissions of greenhouse gases include significant contributions from the agricultural sector. By measuring the concentrations of CO, CO_2, N_2O, and CH_4 at the surface and at different altitudes within the atmospheric boundary layer, as well as measuring the isotopic signatures, we can better understand how New Zealand can successfully meet our international obligations under the Kyoto Protocol on Climate Change.



The panels show past change and predicted future changes in (a) the production of ozone depleting chemicals, (b) their concentration in the stratosphere, (c) the effect of these chemicals on ozone, and (d) on UV radiation at the surface. Because of the success of the Montreal Protocol, we expect a gradual recovery in ozone over the decades ahead.