What's happening to ozone in this part of the world?

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Abstract. A quick review of NIWA's ozone and UV measurements over New Zealand, trends they indicate, and a reminder about the status of the Antarctic ozone-hole.

Introduction

Over the last couple of years, we have started to see hints of Antarctic ozone recovery, with total chlorine loading reducing, annual Antarctic ozone "holes" shrinking and global ozone levels slowing increasing back up towards 1980 levels (Solomon et al., 2016, Steinbrecht et al., 2017, Strahan et al., 2018). This has caused a media storm of stories about the end of the ozone hole or how the ozone problem has been solved. This is not to discount or diminish the real progress and results of the Montreal Protocol, which are indeed real, but to claim that we are at the end of the ozone hole problem or era is premature. While we do see some signs of an ozone recovery (albeit barely distinguishable trends relative to natural variability), more importantly we need to remember that we are only near the beginning of an extended recovery period that could take several decades to fully return to pre-ozone hole levels (current estimates range from 2060-2080 for a recovery back to pre-1980 ozone-levels). Another relevant question is – what is the equilibrium level of ozone in the present-day atmosphere? Since the current atmosphere is warmer than the 1980s atmosphere and that will affect ozone abundance. What will that "recovered" atmosphere look like? The super-recovery of ozone has been discussed since the early 2000s. Many measurement analyses and model studies have demonstrated that ozone levels are indeed increasing relative to the depths of the full ozone hole period of the 1990s. These studies look at global trends separated into latitudinal bands.

Discussion

NIWA have ozone and UV measurements being made across several sites in New Zealand, as well as Boulder Colorado, Mauna Loa Hawaii, Alice Springs and Melbourne Australia, and Arrival Heights Antarctica. At the Lauder Atmospheric Research Station we have the most comprehensive ozone profile measurement capabilities of any site worldwide. We measure ozone using all 5 of the standard techniques recognised by the Network for the Detection of Atmospheric Composition Change (NDACC) of which Lauder was a founding member. Those measurements include: balloon-borne ozonesondes, total column ozone and Umkehr profiling by Dobson spectrophotometer, microwave radiometry, UV-laser-based LIDAR, and Fourier-transform infrared (FTIR) spectrometry. Total column data from the Dobson spectrophotometer are shown in Figures 1 and 2. For other sites in NZ and elsewhere where we do not have calibrated measurements, we can use an assimilated satellite data set of ozone, merged and corrected based on ground-based Dobson data to infer ozone amounts (Bodeker et al., 2005).

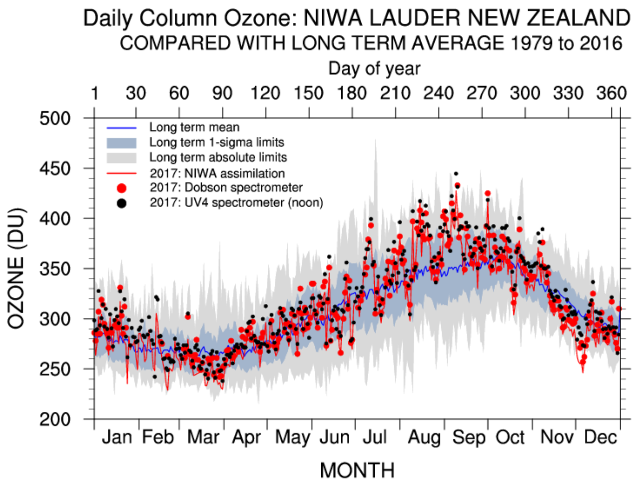

Figure 1. Daily column ozone measurements at Lauder station for 2017 as compared to historical average values and to a satellite assimilated data set. Note the peak in ozone-levels from August to October, the same time of year that the Antarctic ozone-hole develops each Austral Spring. (https://www.niwa.co.nz/our-services/online-services/uv-ozone)

The 30+ year records of ozone we have over New Zealand show little to no trend as the measurement period did not start early enough to include the pre-ozone-hole levels (Zeng et al., 2017). However, these insignificant trends also highlight the relative success of the Montreal Protocol (and subsequent policy amendments) at staving off the destruction of ozone (Morgenstern et al., 2008) and associated increases in UV (Newman & McKenzie, 2011).

Key Points

1- While New Zealand has high UV-levels relative to Northern Hemisphere mid-latitudes (40% higher), the overall level is not large compared to global UVI values, which peak at high altitudes and across the tropics (McKenzie et al., 2006). The problem with UV and high skin cancer levels in NZ is due to a combination of factors: moderate climate, so it is possible to spend more time outdoors (sometimes just to warm up!); relatively clean air (low aerosol loading); and people having a paler skin-type than is suited for these UV-levels (Euro-Caucasian).

2- Related to the "high" UV-levels in NZ (see above in point 1), these levels are NOT due to NZ being under the Antarctic ozone hole. Each Spring, when the Antarctic ozone hole is near its peak, there are even some parts of Antarctica that are not under the "hole", not to mention NZ which is some 3000 km further North. NZ is under a ridge of high ozone during the

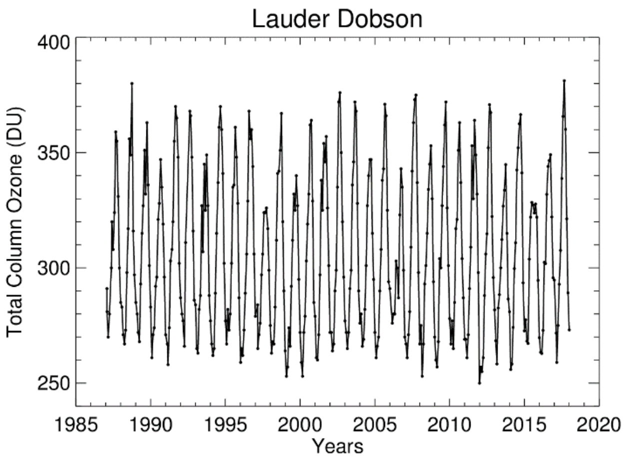

Figure 2. Monthly mean column ozone measurements at Lauder station from 1987 to 2018 using Dobson spectrophotometer #072. Note: there is an implicit clear-sky bias in the Dobson data since measurements cannot be made under heavy cloud cover conditions.

ozone-hole period, having ozone levels near to the highest worldwide during Austral Spring (see Figure 1). After the break-up of the ozone-hole, some of the ozone depleted air is freed to mix with the rest of the atmosphere and combined with dynamics may result in the lower ozone values seen over NZ during Summer and Autumn.

3- The Antarctic ozone-hole continues to be an annual phenomenon. While there are some indications that their intensity and duration may be decreasing, this is speculative and confirmation will require on-going monitoring of the atmospheric conditions over Antarctica for decades to come. Assumptions about the continued "healing" or recovery also presuppose strict adherence to worldwide CFC production bans, again, requiring continued monitoring of global ozone-levels for many years to come.

Conclusion

Media stories about having "solved" the ozone-hole problem may make for good press, but they are not telling the entire, more complicated story. Teasing out the small trends that represent an ozone recovery require high quality, decadal observations. This monitoring needs to continue if we are to have the best available evidence to properly characterise the atmosphere and correctly distinguish the attributes of an ozone-hole recovery from climate change and natural variability.

Acknowledgments

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