Global Ozone and Its Variability

Brian J. Connor, Greg E. Bodeker, and Richard L. McKenzie

National Institute of Water and Atmospheric Research (NIWA), Lauder, New Zealand

Abstract. We report on highlights of current understanding of global ozone. Its decline, which was primarily due to anthropogenic Cl and Br, has been arrested. We also examine the effects of recent ozone changes on summertime UVI in New Zealand, and show that the Antarctic ozone hole is a key factor in its variation.

Research and Assessment Activity

The Total Ozone Monitoring Satellite (TOMS) series of has been the workhorse of global ozone measurements since 1978. The TOMS series has come to an end with the suspension of processing data from the Earth Probe satellite at the end of 2005.

The Ozone Monitoring Instrument (OMI), a US/Netherlands/Finland collaborative effort flying on NASA’s Aura satellite, is slated to be TOMS’ successor. OMI has been producing global ozone measurements since September 2004.

The World Meteorological Organization’s (WMO) quadrennial “Scientific Assessment of Ozone Depletion” has been peer reviewed, is now undergoing a final revision, and will be published later this year.

Global Ozone: Highlights of Current Understanding

One of the global data sets used by the WMO is the NIWA analysis, which integrates data from several US and EU satellites with a global set of ground stations (Bodeker et al, 2005). Figure 1 illustrates the NIWA data set, and shows the change in the global mass of ozone since 1979-81. (For reference, the global mass of ozone is roughly 3 x 10^{12} kg, or 3 billion tonnes.)

Global total ozone decreased through the early 1990’s until it had declined about 5%. It has changed little since 1998, and is still about 3% below pre-1980s values. What drives changes in global ozone? The principal driver of global ozone change has been anthropogenic halogen increases. This is clear both from the observed correlation of long-term trends in ozone and stratospheric Cl and Br, and from our quantitative understanding of the chemistry involved.
There have also been several other contributors. Aerosol loading has been important, principally by providing surfaces for Cl and Br chemistry. This effect is complex and uneven. The solar cycle also has an effect, estimated at 2-3% peak-to-trough.

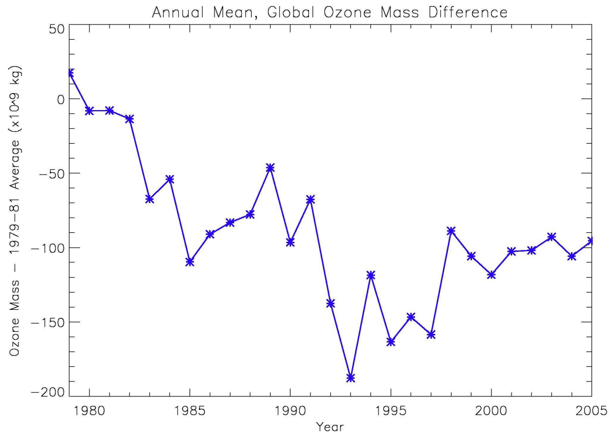

Figure1. Global ozone mass compared to the mean values of 1979-1981.

In a significant development, it now appears that in NH mid-latitudes, approximately half the maximum values of ozone reduction have been due to a long-term change in circulation. The cause of this change is unknown.

NH mid-latitude ozone loss has generally been less than in the SH (Figure 2). SH losses averaged over 30°-60° latitude are similar in all seasons, but are greatest in summer at the latitude of New Zealand.

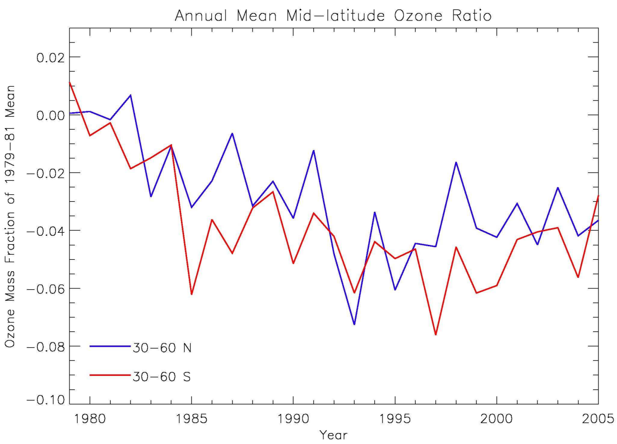

Figure 2. Fractional ozone depletion at mid-latitudes relative to the 1979-81 values.

The effect of the Mt. Pinatubo eruption in 1991 is striking in the NH, where ozone values were low for several years, but the absence of such an effect in the SH is a mystery. Another unsolved puzzle is the cause of the large drop in SH ozone in 1984-85.

The observed ozone losses occurred mainly in 2 altitude bands: roughly 15-25 and 35-45 km. Depletion in the upper region was predicted as much as 35 years ago to be caused by Cl from CFCs. Loss in the lower region, however, dominates loss in the total ozone column due to greater atmospheric mass at those heights. It was discovered in the mid 1980s in the Antarctic, and is due to Cl and Br surface chemistry.

Ozone loss in the Arctic has been much less severe and more uneven than in the Antarctic. It worsened substantially through the early to mid 1990s, rebounded in 1998 and has seen little trend since. However, Antarctic ozone loss has been less severe since 2000 than in the 5 years previous. The reasons for this amelioration are unclear, although in one year (2002) it was driven by a dramatic anomaly in stratospheric 'weather' in the SH.

Relation to UV in New Zealand

McKenzie et al, 1999, reported increases in peak summer values of the UV Index (UVI) at Lauder, NZ (45ºS), caused by decreases in ozone. Fortuitously, this paper coincided with highest UVI values ever recorded at the site.

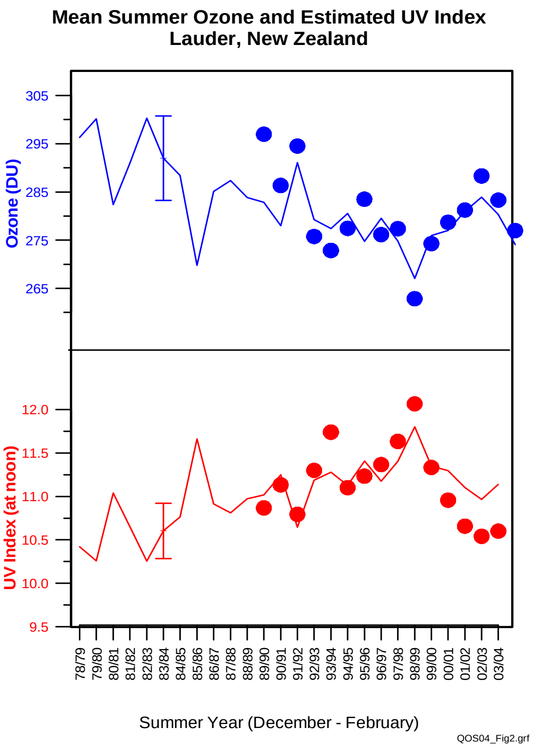

Figure 3. Summer O_3 and UVI at Lauder, NZ

Since that time, peak UVI has declined substantially, and is now comparable to values of 1990 (Figure 3). This decline coincides with an increase in mean ozone values, and is approximately quantitatively consistent with it. The UVI decline is, however, somewhat greater than implied by the ozone increase; the significance of this discrepancy is unclear.

It has been observed that ozone at mid-latitudes in SH summer is strongly correlated with ozone loss in that year's ozone hole (Figure 4), and further that peak UVI at Lauder is strongly coupled to mean summertime ozone at SH mid-latitudes. It follows that summer UVI is tied to Antarctic ozone loss in the preceding spring. Thus, peak summer UVI has decreased in 2000-05, at least in part, because the ozone hole has been less intense.

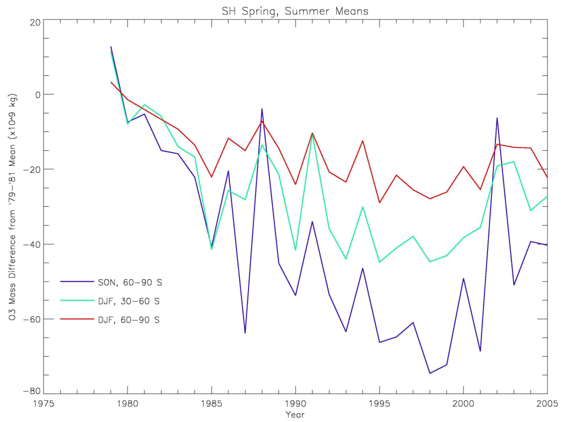

Figure 4. Springtime Antarctic ozone compared to summertime ozone at mid- and polar latitudes.

Recovery?

The ozone decline driven by anthropogenic Cl and Br has clearly stopped. This is a result of reductions in the Cl and Br source gases, and thus due to the Montreal Protocol and subsequent revisions. However the large year-to-year variability may make it be too early to say that ozone is 'recovering,' i.e. increasing, due to decreases in anthropogenic Cl and Br.

References

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