Twenty-five years of ozonesonde measurements at South Pole: An assessment of changing loss rates

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Introduction

In 2010, 25 years of regular, year-round ozone soundings at South Pole station, Antarctica, were completed (Figure 1). This unique vertically resolved data set was analyzed to evaluate the temporal development of ozone loss rates as a function of altitude. In combination with predictions of future concentrations of ozone depleting substances, it was possible to estimate the time when future ozone loss rates will be lower than the peak loss rates by an amount large enough to be observable outside the range of dynamical variability.

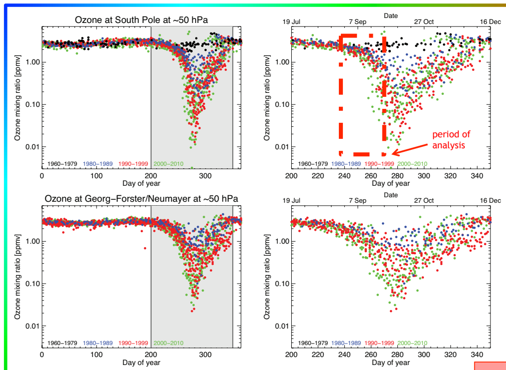

Figure 1: Ozone mixing ratio at ~50 hPa at South Pole station (upper panel) and Georg- Forster/Neumayer station (lower panel) for four time periods: 1960-1979, 1980-1989, 1990-1999, 2000-2009. The grey shaded areas in the graphs of the left column are expanded in the right column. Note that measurements for the first period are only available for some years at South Pole, and no data are available then at Georg-Forster/Neumayer station.

Method (loss rates)

Ozone loss rates are determined between end of August and beginning of October, when ozone depletion is fastest and dynamical influences (e.g. diabatic descent) on loss rates are very small compared to chemical influences. To further reduce dynamical influences (e.g. QBO) 5 years of data are combined. Different pressure levels are analyzed separately by fitting a straight line to all available measurements (Figure 2 & 3).

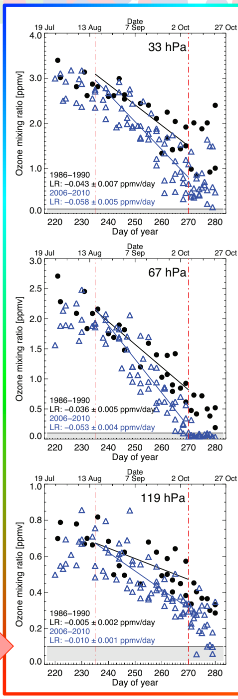

Figure 2: Ozone measurements at South Pole at three different pressure levels and during two different 5-year periods, 1986 to 1990 (black circles) and 2006 to 2010 (blue triangles), as a function of day of the year. A linear fit (black and blue solid lines) was performed for measurements taken between day 235 (end of August) and day 270 (end of September) of each time period (red dashed lines). For all three shown pressure levels, the differences in slopes are significant. The minimum ozone threshold for the fitting procedure was set to 0.1 ppmv (dark grey line and grey box).

Method (projection)

If a linear relationship between ozone loss rates and EESC concentration in the Antarctic stratosphere is assumed, it is possible to project future ozone loss rates with assumed future EESC concentrations (Figure 4). A loss rate profile representative for peak EESC concentrations is created and compared to future loss rate profiles that are calculated according to predicted EESC concentrations. Considering uncertainties on the loss rates of the peak and the future loss rate profiles, it is possible to detect when ozone loss will be measurably slower than it was at the peak.

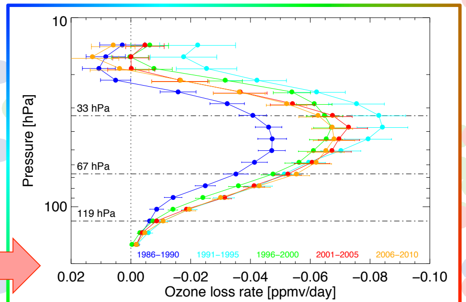

Figure 3: Profile of loss rates for five time periods (1986-1990, 1991-1995, 1996- 2000, 2001-2005 without 2002, 2006-2010) at South Pole, as determined by a linear fit to all available data for each pressure level between day 235 and day 270. Loss rates are given in [ppmv/day]. Error bars represent 1-σ uncertainties.

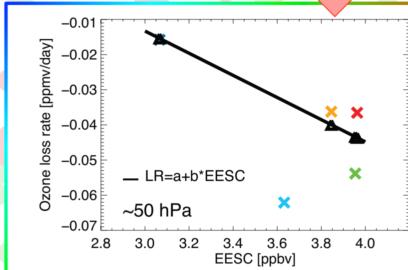

Figure 4: Dependence of ozone loss rates of the past 25 years (colored crosses) on EESC (equivalent effective stratospheric chlorine) concentrations described with a linear relationship (1991-1995 period, turquois cross, excluded).

Reference

Hassler, B., J.S. Daniel, B.J. Johnson, S. Solomon, and S.J. Oltmans (2011), An assessment of changing ozone loss rates at South Pole: Twenty-five years of ozonesonde measurements, *J. Geophys. Res.*, doi:10.1029/2011JD016353, in press.

Results

In the period 2017-2021 the first change in lower stratospheric ozone loss rates at South Pole will be detectable around ~90 hPa (Figure 5), and by 2026-2030 loss rates of all pressure levels between around 100 hPa and 20 hPa are projected to be significantly reduced (Figure 6).

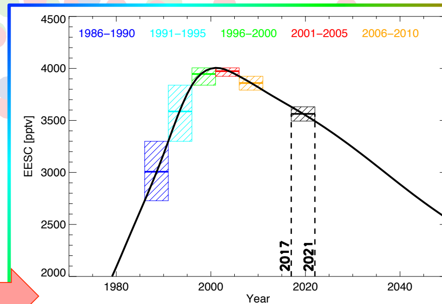

Figure 5: EESC concentration time series for a mean age-of-air of 5.5 years. Overlaid are the mean EESC values for the five 5-year periods analyzed, color-coded as shown at the top of the graph. The black box shows the 5-year period for which the loss rates are significantly lower than peak loss rate at the first pressure level (~90 hPa), considering the uncertainties on the loss rate.

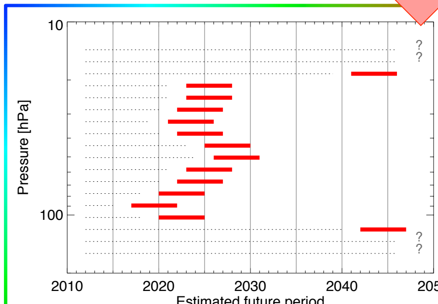

Figure 6: Estimated 5-year periods (red bars) in which differences between the peak loss rate profile and the future loss rate profile become significant.