Trend and solar cycle in stratospheric ozone profiles over Switzerland

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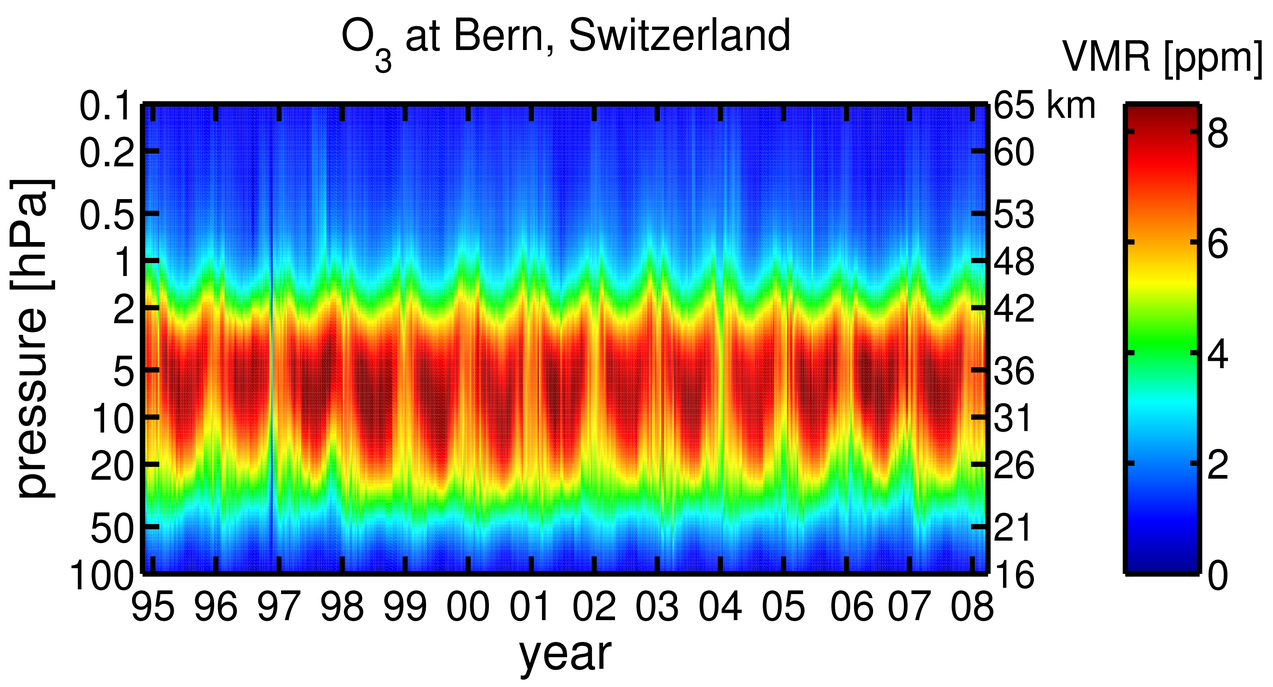
Introduction:

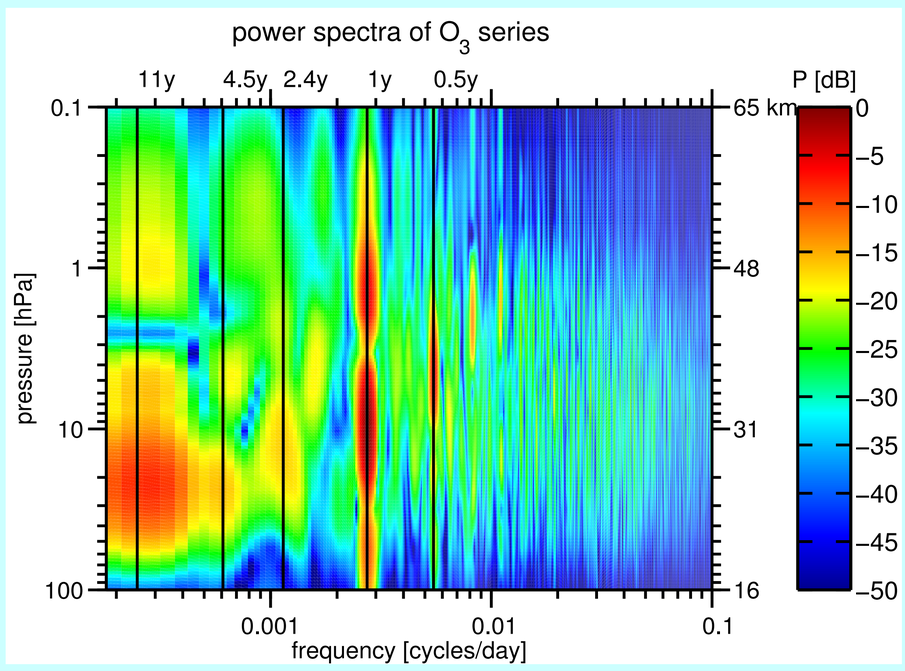
Ground-based ozone microwave radiometers measure at all daytimes and under nearly all weather conditions. Thus ground-based microwave radiometers can indeed monitor the long-term changes of the mean state of stratospheric ozone -- without serious, systematic data gaps in the time domain.

The microwave radiometer GROMOS at Bern measures ozone line spectra at 142 GHz with a time resolution of 3 min since November 1994. The spectra are inverted into ozone profiles with a vertical resolution of about 10 km and are sent to the AVDC and NDACC data centers. We reprocessed all spectra with ARTS/Qpack inversion software and obtained nearly complete series of ozone profiles on a fixed pressure grid. We use these ozone series for a trend analysis.



Data analysis:

The *a priori* ozone profiles depend on the month but not on the year. Thus we can derive the long-term trend and the solar cycle variation of ozone as function of pressure level.



1) remove outliers (> 10 sigma)

2) compute power spectra of ozone series (Lomb-Scargle periodogram) to find the dominant spectral components

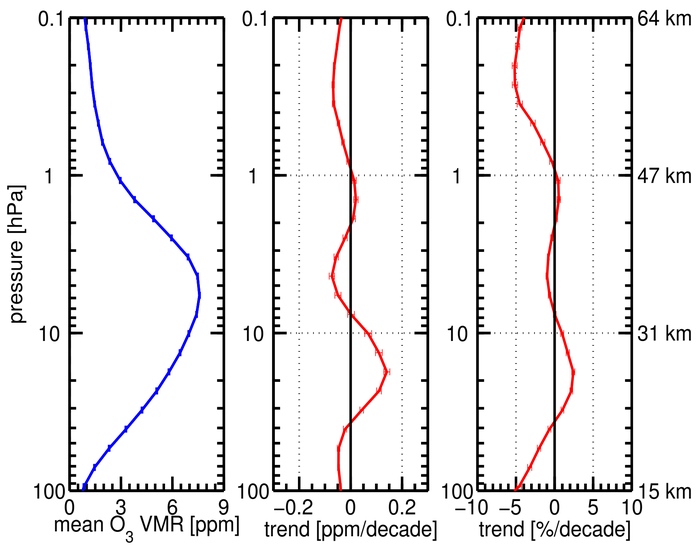
3) close the few data gaps of ozone series by means of linear interpolation (for removal of systematic data gaps due to very humid summer days)

4) multiple linear regression of ozone series with a constant, linear trend, 11-year, 4.5-year, QBO (2.4- year) sine and cosine waves

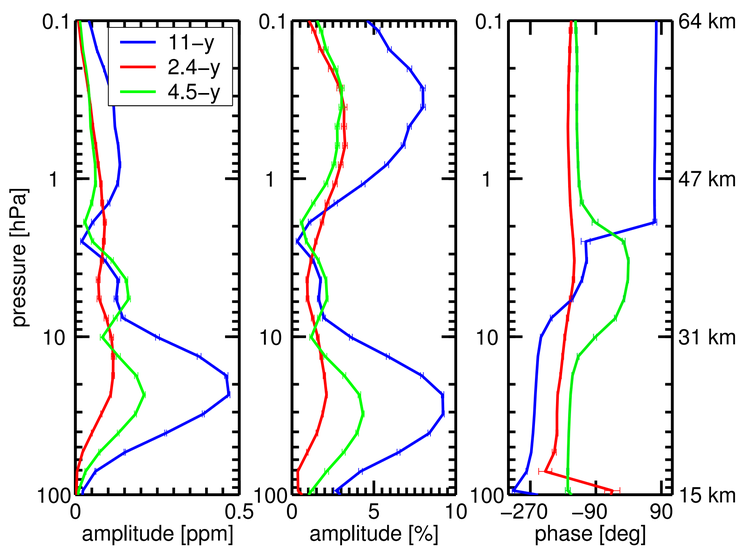
5) multiple linear regression of the residual with annual and semi-annual components

Results for the ozone series (Jan.1995 - Jan.2008):

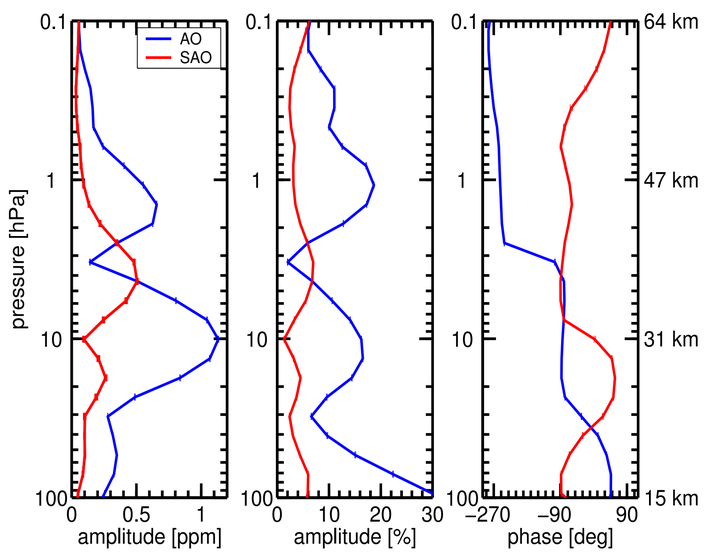
Mean profile + linear trend:



Solar Cycle, QBO, and 4.5-year components:



Annual + semi-annual components:



- linear trend within ±3% per decade at stratospheric altitudes beyond 20 km
- strong solar cycle (up to 9%), peaking around solar maximum in lower stratosphere and mesosphere
- phase reversal of annual oscillation and solar cycle (at 2 hPa level)

Conclusions:

Data from ground-based optical and infrared remote sensing techniques and satellites have serious limitations in the time coverage. Trend analyses of these data sets raise the question if the derived trends are valid for the mean state of ozone? Thus the analysis of almost complete ozone series from ground-based microwave radiometers provides invaluable information on long-term changes of ozone.