Stratospheric ozone recovery at mid-latitudes: improved ground-based time series and trend estimations

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Monitoring the recovery of stratospheric ozone is essential to verify the effectiveness of the Montreal Protocol. After the protocol banned ozone depleting substances, first signs of an ozone recovery in the stratosphere were observed starting in 1997. Recent studies have confirmed that mid-latitudinal ozone is increasing in the middle stratosphere due to chemical and dynamical effects, whereas evidence for a continuous decrease in the lower stratosphere exists. To improve trend estimations of stratospheric ozone profiles, continuous and stable time series are crucial and trend uncertainties need to be addressed.

We present an updated and improved 23-years time series of stratospheric ozone from the GROMOS (GROund-based Millimeter-wave Ozone Spectrometer) microwave radiometer located at Bern, Switzerland, that provides ozone profiles from 20-50km. We compared the data with other ground-based instruments in central Europe from the Network for the Detection of Atmospheric Composition Change (NDACC). Based on the different data sets we estimated trends of stratospheric ozone volume mixing ratios (VMR) with a multilinear trend model that can handle uncertainties in a flexible way. The datasets show positive ozone VMR trends of 2-4% in the middle stratosphere (25-40km), and biased results in the lower stratosphere. Our study further elucidates how trend estimates of stratospheric ozone are influenced by factors such as uncertainties of the underlying ozone data, sampling rate and period length. The GROMOS data are well suited to investigate such factors thanks to the long and complete time series and the high temporal resolution.

Key words: Stratospheric ozone recovery, ozone trends, northern mid-latitudes, ground-based remote sensing, microwave radiometry