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# First detection of a seasonality of stratomesospheric CO above mid-latitudes via solar FTIR measurements. Analysis of one decade of observations at the NDACC Primary Station Zugspitze

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Model studies revealed that stratomesospheric CO exhibits considerable seasonal and latitudinal variations caused by the competition between downward transport from the thermospheric production region and photochemical loss processes. A sharp latitudinal gradient with highest abundances at the North Pole was found which implies that the mid-latitude region can exhibit strong enhancements of stratomesospheric CO under conditions of large-scale planetary wave activity displacing CO enriched vortex air from North to South. Unfortunately, until now there are not enough continuous long-term measurements of stratomesospheric CO at mid-latitudes to prove this assumption.

Velazco et al. [2007] reported ground-based FTIR measurements of stratomesospheric CO partial columns from several sites in the Arctic, northern and southern mid-latitudes, and Antarctica. Unfortunately, this study concluded that, generally, the mid-latitude stations show no significant annual variability of stratomesospheric CO columns. However, already early microwave observations indicated that stratomesospheric CO is about twice as large in mid-latitude winter as in summer [Clancy et al., 1982]. Obviously, there was a technical difficulty with the FTIR inversion of mid-latitude mesospheric CO in the early study by Velazco et al. [2007].

It is one aim of this paper to present a solution to this problem. Therefore, this paper describes an improved retrieval approach for ground-based FTIR stations, that is capable to derive a significant seasonal cycle of stratomesospheric CO at mid-latitudes. Coincident measurements at Zugspitze (2964 m a.s.l.) and Garmisch (744 m a.s.l.) show perfect agreement (R = 0.94) which proves that the new retrieval approach is not limited to high altitude stations, and is thus applicable to all mid-latitude stations. The first long-term series of stratomesospheric CO at mid-latitudes (42.42°N, 10.98°E) derived from ground-based FTIR spectrometry is presented (1999 to 2008). Between November and April the monthly mean time series shows column enhancements by a factor of 2.2 relative to the summer minimum of 1.64E16 cm-2 with a maximum of 3.63E16 cm-2 in February and strong year-to-year variability of up to 32 % (1 sigma). The seasonality agrees very well with the WACCM model [Garcia et al., 2007] which, however, can not reproduce measured year-to-year variability. Pronounced short time enhancements (duration of 1 to 3 days) are observed, which during winter exceed the monthly-mean background seasonality by up to 276 %. Comparison with WACCM and FTIR measurements at high-latitudes [Jones et al., 2007] reveal, that these enhancements reflect inner vortex conditions and are due to transport by planetary waves.

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