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How Tropospheric is Tropospheric Ozone?

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There has been a long debate on the reasons of the increase in tropospheric ozone during the past century. Mostly the photochemical ozone formation combined with the growing level of air pollution has been stressed. However, with decreasing European precursor emissions in the 1990s and the ongoing positive trend of O3 at the high-lying Alpine station Zugspitze (2962 m a.s.l.) until about 2000 this view has started to change. Data filtering of the Zugspitze data based on relative humidity (RH), 7Be and CO measurements have revealed that the only positive ozone trend could be found for descending air masses of dominating stratospheric origin whereas the trend for polluted air masses is around zero. The 7Be data, recorded since 1970, showed a positive trend since the mid-seventies. Based on daily model forecasts by ETH of stratospheric air intrusions co-ordinated lidar measurements of ozone and, more recently, water vapour (Vogelmann and Trickl, 2008) have been carried out. It could be shown that there is an excellent agreement between the intrusion forecasts, the lidar measurements and low-RH events at the Zugspitze summit (Trickl et al., 2010). The forecasts also allowed us to define intrusion types as well as to review and to revise the data-filtering criteria used for the in-situ data. This study, carried out for the period 2001-2005, yields a significantly higher number of intrusions reaching 3000 m than obtained in previous investigations, with even about 20 per cent more cases (mostly overpasses) predicted by the forecasts. Seasonal cycles of the intrusion frequency were derived and, in all but one intrusion type, peaked during the cold season. Recent measurements with the water-vapour lidar (see parallel contribution) have revealed RH values of 0-2 per cent even in very thin layers of stratospheric origin reaching the lower troposphere. This indicates that significant mixing with tropospheric air can only occur during the early phase of an intrusion, if not stirring occurs at later times. This suggests that the results of filtering the Zugspitze data based on stratospheric criteria should be rather quantitative. A preliminary estimate of the overall stratospheric fraction of the Zugspitze ozone has almost doubled since the seventies.

References

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