HOW STRATOSPHERIC ARE STRATOSPHERIC AIR INTRUSIONS?

Thomas Trickl, Hans-Eckhart Scheel and Hannes Vogelmann
Karlsruher Institut für Technologie, IMK-IFU, Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen, Germany; telephone: +49-8821-183-209; fax: +49-8821-73573; e mail: thomas.trickl@kit.edu

The continual increase of ozone and ^{7}Be at the Alpine summit station Zugspitze (2962 m a.s.l., Garmisch-Partenkirchen, Germany) between the mid-seventies and 2000 has led to systematic efforts for identifying and quantifying its reasons, starting in the late 1990s (STACCATO and ATMOFAST projects). Data filtering by Scheel based on the ozone, relative-humidity (RH) and ^{7}Be measurements, has shown that the only strong positive trend in the Zugspitze ozone between the seventies and 2000 is related to air masses descending in deep stratospheric intrusions. The stratospheric contribution to the Zugspitze ozone has roughly doubled to about 20 ppb since the beginning of the observations 1978, the impact being much lower at the neighbouring site Wank (1780 m a.s.l.). It is reasonable to speculate on a climate-related origin of this increase in ozone, and also of its end after 2000. In recent years we have refined the data-filtering approach, based on ^{7}Be and relative humidity, which has led to a revision of the analysis (1978-2010). The quality of the results, however, significantly depends on the degree of mixing of the stratospheric air tongues with tropospheric air. However, in many years of humidity sounding with our differential-absorption water-vapour lidar we found that even in very thin layers the relative humidity mostly stays in the range between 0 and 2 %. This result suggests that mixing occurs in the upper troposphere and the lower stratosphere (UTLS). It is also difficult to explain the characteristic strong drop in ozone in the subsiding stratospheric ozone layers in the time series of our ozone lidar to typically 50 to 80 ppb by mixing. We think that our observations in the Northern Alps to some extent map the vertical trace-gas distributions in UTLS of the Arctic source regions. A smooth transition from tropospheric to stratospheric air in the source region is also consistent with the low to moderate drop of the Zugspitze CO mixing ratio during intrusion periods. It is important to note that the average CO in direct stratospheric intrusions has slightly grown since the beginning of the measurements in 1990 indicating some input into the UTLS range from regions with growing air pollution.