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Tracing troposphere-to-stratosphere transport above a mid-latitude deep convective system

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Abstract. Within the project SPURT (trace gas measurements in the tropopause region) a variety of trace gases have been measured in situ in order to investigate the role of dynamical and chemical processes in the extra-tropical tropopause region. In this paper we report on a flight on 10 November 2001 leading from Hohn, Germany (52°N) to Faro, Portugal (37°N) through a strongly developed deep stratospheric intrusion. This streamer was associated with a large convective system over the western Mediterranean with potentially significant troposphere-to-stratosphere transport. Along major parts of the flight we measured unexpectedly high NO_y mixing ratios. Also H_2O mixing ratios were significantly higher than stratospheric background levels confirming the extraordinary chemical signature of the probed air masses in the interior of the streamer. Backward trajectories encompassing the streamer enable to analyze the origin and physical characteristics of the air masses and to trace troposphere-to-stratosphere transport. Near the western flank of the intrusion features caused by long range transport, such as tropospheric filaments characterized by sudden drops in the O_3 and NO_y mixing ratios and enhanced CO and H_2O can be reconstructed in great detail using the reverse domain filling technique. These filaments indicate a high potential for subsequent mixing with the stratospheric air. At the south-western edge of the streamer a strong gradient in the NO_y and the O_3 mixing ratios coincides very well with a sharp gradient in potential vorticity in the ECMWF fields. In contrast, in the interior of the streamer the observed highly elevated NO_y and H_2O mixing ratios up to a potential temperature level of 365 K and potential vorticity values of maximum 10 PVU cannot be explained in terms of resolved troposphere-to-stratosphere transport along the backward trajectories. Also mesoscale simulations with a High Resolution Model reveal no direct evidence for convective H_2O injection up to this level. Elevated H_2O mixing ratios in the ECMWF and HRM model are seen only up to about tropopause height at 340 hPa and 270hPa, respectively, well below flight altitude of about 200 hPa. However, forward tracing of the convective influence as identified by satellite brightness temperature measurements and counts of lightning strokes shows that during this part of the flight the aircraft was closely following the border of an air mass which was heavily impacted by convective activity over Spain

and Algeria. This is evidence that deep convection at mid-latitudes may have a large impact on the tracer distribution of the lowermost stratosphere reaching well above the thunderstorms anvils as claimed by recent studies using cloud-resolving models.

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