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Stratospheric and tropospheric NO_2 variability on the diurnal and annual scale: a combined retrieval from ENVISAT/SCIAMACHY and solar FTIR at the Permanent Ground-Truthing Facility Zugspitze/Garmisch

R. Sussmann[1], W. Stremme[1], J. P. Burrows[2], A. Richter[2], W. Seiler[1], and M. Rettinger[1]
[1] IMK-IFU, Forschungszentrum Karlsruhe, Garmisch-Partenkirchen, Germany
[2] Institute of Environmental Physics, University of Bremen, Bremen, Germany

Abstract. Columnar NO_2 retrievals from solar FTIR measurements at the Zugspitze (47.42° N, 10.98° E, 2964 m a.s.l.), Germany were investigated synergistically with columnar NO_2 retrieved from SCIAMACHY data by the University of Bremen scientific algorithm UB1.5 for the time span July 2002-October 2004. A new concept to match FTIR data to the time of satellite overpass makes use of the NO_2 daytime increasing rate retrieved from the FTIR data set itself [+1.02(6)E+14 cm^{-2}/h]. This measured increasing rate shows no significant seasonal variation. SCIAMACHY data within a 200-km radius around Zugspitze were considered, and a pollution-clearing scheme was developed to select only pixels corresponding to clean background (free) tropospheric conditions, and exclude local pollution hot spots. The resulting difference between SCIAMACHY and FTIR columns (without correcting for the different sensitivities of the instruments) varies between 0.60-1.24E+15 cm^{-2} with an average of 0.83E+15 cm^{-2}. A day-to-day scatter of daily means of ≈7-10% could be retrieved in mutual agreement from FTIR and SCIAMACHY. Both data sets are showing sufficient precisions to make this assessment. Analysis of the averaging kernels gives proof that at high-mountain-site FTIR is a highly accurate measure for the pure stratospheric column, while SCIAMACHY shows significant tropospheric sensitivity. Based on this finding, we set up a combined a posteriori FTIR-SCIAMACHY retrieval for tropospheric NO_2, based upon the averaging kernels. It yields an annual cycle of the clean background (free) tropospheric column (<10 km) with variations between 0.75-1.54E+15 cm^{-2}, an average of 1.09E+15 cm^{-2}, and an intermediate phase between that of the well known boundary layer and stratospheric annual cycles. The outcome is a concept for an integrated global observing system for tropospheric NO_2 that comprises DOAS nadir satellite measurements and a set of latitudinally distributed mountain-site or clean-air FTIR stations.

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