

## **Long-term MAX-DOAS measurement of trace gases and aerosol in the Environmental Research Station Schneefernerhaus**

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The Environmental Research Station Schneefernerhaus (Umwelt Forschungsstation Schneefernerhaus, UFS) is located immediately under the summit of Zugspitze (2962 m), the highest mountain of Germany, at a height of 2650 m. The UFS is a rare observation site in Germany with mostly clean and unpolluted air. It is ideal for both stratospheric composition measurements and trace gas measurements in the free-troposphere. It is optimal for detecting pollution events in the free-troposphere, which are indications of short- or long-range transport of air pollutants.

A MAX-DOAS instrument has been working in the UFS since February 2011. With the zenith spectrum of each cycle used as the reference, the differential slant column densities (DSCDs) of trace gases are calculated from the spectra with Differential Optical Absorption Spectroscopy (DOAS) method. The DSCDs of both  $O_4$  and  $NO_2$  are calculated in two different wavelength intervals, 338-370 nm in the UV region and 440-490 nm in the VIS region. For HCHO and HONO, optimal fitting windows have been determined in the UV region. A retrieval algorithm, based on the radiative transfer model LIDORT and the optimal estimation technique, is used to provide information on the vertical profiles and vertical column densities (VCDs) of aerosol and trace gases.

Meanwhile, zenith-sky radiance spectra during twilight hours are analyzed using DOAS method to derive the total vertical column densities (VCDs) of  $O_3$  and  $NO_2$ . A zenith spectrum measured in the noon of a summer day was chosen as the reference spectrum. The slant column densities (SCDs) of  $O_3$  and  $NO_2$ , which are the direct product of the DOAS analysis, are then converted into VCDs using the air mass factors (AMFs) derived by radiative transfer calculations.

This work presents the results of the MAX-DOAS measurement in the UFS from 2012 to 2015, including aerosol (derived from  $O_4$  measurement),  $NO_2$ , HCHO, and HONO, etc. The vertical profiles as well as the seasonal and diurnal variation patterns of tropospheric aerosol and trace gases will be shown. The total VCDs of  $O_3$  and  $NO_2$ , as well as a comparison between MAX-DOAS measurement and satellite measurement will also be shown. In the end, high  $NO_2$  episodes in the UFS due to long range transport of air pollutants will be presented.