**DOAS Setup**

The Bremian DOAS network for atmospheric measurements (BREDOM) is a network of high quality UV-visible spectrometers for atmospheric observations that has been setup by the University of Bremen, Germany. The aim is to provide long-term, continuous measurements of a number of stratospheric and tropospheric species at latitudes ranging from the Arctic to the equator. This is particularly useful for satellite validation, as a broad range of atmospheric situations (summers' winter, high/low ozone, vortex/ non vortex conditions, changing albedo, cloud cover, ...) and also of different measurement conditions (high/low solar elevation) is covered. In addition, the network is also well suited for studies of tropospheric pollution (e.g. biogenic emissions), as all instruments are equipped with the MaxX (multi-axis) DOAS technique. 

An important step in passive remote sensing was the development from ground-based zenith sky observations to multi-axis measurements [1], which has enabled us to validate findings from satellite observations and study the behaviour of important trace gases in the troposphere on a local scale. Applying the Optimal Estimation Method [3] to measured slant columns yield profile information on numerous trace gases in the troposphere [2].

Sunlight scattered from the sky is collected by a telescope (Fig 1) and transmitted to a Czerny-Turner spectrograph via a de-scattering quartz fibre. A charge coupled device (CCD) is used as a detector. The pointing of the telescope alternates between zenith and four off-axis directions (0° to 30° above horizon), which provides profile information of the absorbers. The time resolution is usually 5 minutes for a complete measurement cycle. The observation in different lines of sight is realized by a motor fixed on a revolving table driven by a computer-controlled stepper. The whole system works automatically and the measurement parameters can be set from Bremen via an internet connection.

**Profile Retrieval: BREAM**

BREAM: Bremen advanced MAX-DOAS retrieval algorithm

Recent studies [4,1] have shown that the measured slant column of the oxygen dimer O$_2$ can be used to derive aerosol information, i.e. the extinction profile and some aerosol properties (e.g. HCHO).

In a first step the algorithm uses the radiation transport model SCIAMACHY [5] to calculate O$_2$ slant columns which are compared to the measured ones in order to reduce uncertainties due to aerosols.

The extinction profile in its total quantity as well as in its structure (i.e. the height of the boundary layer) is scaled in an iterative process and therewith the slant columns of O$_2$ are calculated. The quality of the agreement is evaluated by applying two parameters: The correlation between the measurement and the model column (which is mainly influenced by the height of the boundary layer) and the mean deviation of those (mainly modulated by the extinction).

The second step comprises calculation of so-called block air mass factors with respect to the chosen absorber (e.g. HCHO) and the previously obtained aerosol information. Again SCIAMACHY in its full-spherical mode is operated. Block air mass factors are air mass factors which depend on the layer height of the absorber. The overall air mass factor is simply the average of the block air mass factors weighted by the distribution of the trace gas. This concept allows us to discrete the measurement into the set of slant columns under different elevation angles of the absorber) and the absorber’s profile in the atmosphere as a linear system. To solve such a linear system the well-known and in atmospheric chemistry long-established method of Optimal Estimation by Rodgers [5] is applied.

**Vertical Resolution**

The averaging kernel matrix is a measure for the quality of the retrieval. The trace of the matrix determines the number of pieces of independent information with respect to the height layers, i.e. the degrees of freedom of this measurement. Typical integration times (20 minutes to one hour) together with the moderate aerosol content yields a number of about two to three. The whole range includes results from about 1.5 for low visibility up to about five considering also large solar zenith angles (SZA > 75°). An example for the averaging kernel matrix and the corresponding retrieved profile is shown in Figure 2.

Furthermore the optical depth and other aerosol features can be retrieved using the method described above.

This study shows time series for tropospheric amounts of NO$_2$, and HCHO for selected BREDOM stations and for different field campaigns. In addition selected data sets have been examined for aerosol properties. These data sets have been compared to other ground-based data.

**References**


**References**


