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Inference of cloud altitude and optical properties from MAX-DOAS measurements

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Multi-Axis Differential Optical Absorption Spectroscopy (MAX-DOAS) is a widely used technique for the detection of atmospheric trace gases, e.g. NO_2, SO_2, BrO, HCHO, but also for the oxygen collision complex O_4. The atmospheric distribution of the latter is proportional to the square of the molecular oxygen concentration and thus well known. By comparing measured O_4 differential slant column densities (dSCDs) from MAX-DOAS measurements with modeled ones, information on aerosol distributions and optical properties, as well as on clouds can be obtained using an algorithm based on optimal estimation.

Here the ability of MAX-DOAS observations to detect cloud altitude and cloud optical properties of different cloud covers based on measurements of O_4 will be discussed. The analysis uses measurements made by a shipborne instrument on two cruises of the German research vessel Polarstern to the Antarctic Weddell Sea from June to October 2013. During this time a broad range of cloud and aerosol conditions was encountered, in particular persistent low cloud cover with a high optical thickness.

Aerosol and particle extinction profiles were retrieved with temporal resolutions of up to 15 minutes. For clouds at altitudes up to 2000 m the results show a very good agreement with co-located measurements of a commercial ceilometer and pictures from a cloud camera. Unless visibility was very poor due to fog, even rapid changes in cloud altitude or cover could be detected by MAX-DOAS. These results indicate that under homogeneous cloud cover an accurate retrieval of trace gas vertical profiles can be possible despite the strong influence of clouds on atmospheric light paths. We will discuss advantages and limitations of cloud detection with MAX-DOAS, implications for the subsequent retrieval of trace gas profiles and the possible use of external (ceilometer) data as a priori information for the profile retrieval algorithm.