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Autonomous long-term trace gas measurements using Long-Path Differential Optical Absorption Spectroscopy

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Long-Path DOAS (Differential Optical Absorption Spectroscopy) is a well-established, very specific and reliable remote sensing technique for the observation of a large variety of trace gases. So far DOAS has been mostly applied in the UV-Vis spectral region; detectable species are for example ClO, OClO, BrO, OBrO, IO, OIO, I_2, OIO, O_3, formaldehyde, glyoxal, NO_2, H_2O, O_4, or SO_2.

In the Long Path DOAS setup, a dedicated light source and a measurement path of up to 10 km between a telescope and a reflector yield continuous path averaged concentrations independent of solar radiation and still on scales below the ground pixel sizes of satellite instruments.

Here we present an advanced LP-DOAS instrument incorporating several technical improvements to a setup that allows for the first time autonomous and continuous long term measurements with very high measurement accuracy necessary for the measurement of low trace gas concentrations. The setup uses an optical fiber bundle in the telescope for transmission and reception of the measurement signal. The traditional Xe-arc lamp has been replaced by a Laser Driven Light Source with a long life time and very good optical stability. Using this light source also allows an improved wavelength selective coupling from light source into the fiber which reduces stray light. The coupling and configuration of the optical fiber was optimised compared to previous designs to maximise light throughput and reduce stray light. Additionally, the fibers were treated in order to reduce noise caused by irregular grating illumination.

These changes drastically lower detection limits (e.g. to 1 pptv for BrO or 8 pptv for ClO) and improve the long-term reliability. To facilitate an autonomous operation, the measurement software incorporates features such as an automatic reflector search and intensity optimisation as well as a selection from the available measurement paths based on atmospheric visibility. Since January 2016, we are successfully running the LP-DOAS instrument continuously under the challenging environmental conditions of Antarctica at the German Neumayer III station. We present technical features of the instrument with a focus on physical phenomena the technique is based on and limited by and discuss its long-term performance.