Ground-based remote sensing on CH4 by Differential Absorption LiDAR

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Developments in lidar have been driven largely by improvements in two key technologies: lasers and detectors. We describe here a lidar instrument for atmospheric remote sensing using the elastic-backscatter and differential-absorption lidar (DIAL) techniques. The instrument features an all-solid-state laser source combined with photon-counting detection providing portability, eye-safe operation and high sensitivity.

The system is built around a custom-designed Newtonian telescope with a 0.38 m diameter primary mirror. Laser sources and detectors attach directly to the side of the telescope allowing for flexible customization with a range of equipment.

We report the operation of the system with a laser source based on an optical parametric oscillator. The OPO is pumped by an Nd:YLF laser at a wavelength of 1.057 µm. It is angle-tuned by rotating the crystal providing output wavelengths tunable to a maximum extent of 1.6 µm for the signal wave and 3.1 µm for the idler. This provides a wide range of available wavelengths suitable for lidar, all within a spectral region with a relatively high exposure limit for eye safety. The OPO delivers 1 mJ output pulse energy which is expanded and then transmitted coaxially from the telescope.

The use of the 1.6 µm wavelength region provided by the signal wave allows for several direct detection schemes. Tests of the instrument were made with indium gallium arsenide (InGaAs) photodiode detectors and a custom-built multi-stage transimpedance amplifier. These tests demonstrated that the system achieves a ranging precision better than 0.3 m. Whilst photodiode detectors are a very low-cost solution their limited sensitivity restricts the maximum range over which a signal can be detected. We therefore outline the adaptation of the instrument to support photon-counting detectors such as avalanche photodiodes (APDs) and single-photon avalanche diodes (SPADs).

Our goal is to make vertically-resolved measurements of greenhouse gas concentrations using DIAL. A gas cell within the laser source allows the wavelength to be tuned to match a specific absorption feature of CO_2 near 1.6 µm. The source can rapidly be tuned between the on-line and off-line wavelengths to make a DIAL measurement.