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The NAOMI GAZL multispecies differential absorption lidar: realization and testing on the TADI gas leak simulation facility

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Abstract: We report on a differential absorption lidar, designed for remote detection of CH₄ and CO₂, based on a single-frequency 1.57-1.65 μm parametric oscillator/amplifier system. The lidar is tested on a controlled gas release facility. © 2019 The Author(s).

OCIS codes: (190.4970) Parametric oscillators and amplifiers; (280.1910) DIAL, differential absorption lidar.

1. Introduction

Differential absorption lidars (DIAL) are valuable tools for remote detection, localization, and quantification of a gaseous species, for safety applications, as well as for environmental monitoring. DIAL can be tailored to detect species such as CO₂ and CH₄ in the infrared, where they display characteristic absorption features, linked to their vibration modes. In a DIAL, two laser pulses are emitted, at two wavelengths called ON (tuned to the absorption band) and OFF (on an absorption minimum). The laser pulses are backscattered by atmospheric aerosols, collected by a telescope and focused on a photodetector. A gas plume can be localized and quantified by comparing the range resolved ON and OFF signals.

Several systems have been and are currently in development for such applications [1,2]. Here, we aim at developing a compact, range resolved, multi-species system for both CO₂ and CH₄, based a widely tunable, single frequency emitter, with a high conversion efficiency. The emitter is based on a pulsed, nanosecond, single frequency, Nested Cavity Optical Parametric Oscillator (NesCOPO) [3], amplified to 16 mJ, and implemented in a direct detection Lidar system. This Lidar, NAOMI GAZL, is tested on a gas leak tests facility, called TADI for Transverse Anomaly Detection Infrastructure, in the frame of NAOMI project (for New Advanced Observation Method Integration), along with other instruments (for instance hyperspectral imaging).

2. GAZL instrument

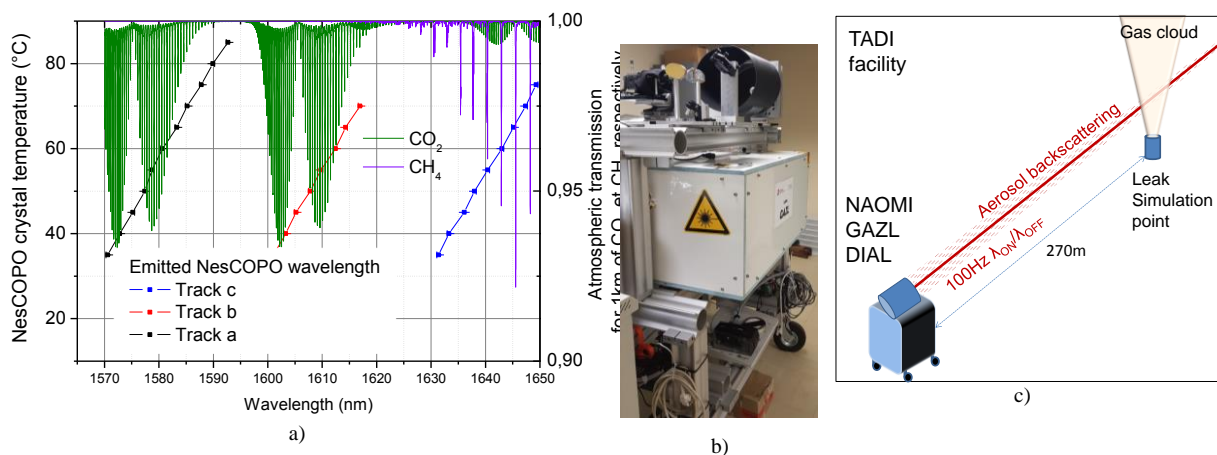


Fig. 1. NAOMI GAZL NesCOPO emitted wavelength as a function of the temperature, for three different PPLN periods a). The atmospheric transmission for CO₂ (for 400 ppm) and CH₄ (for 2 ppm) over 1 km are given. Picture of the NAOMI GAZL lidar b) and deployment of the Lidar on TADI facility c).

The emitter is a NesCOPO emitting in the 1.57-1.65 μm range, based on a multi-track periodically-poled LiNbO₃ (PPLN) crystal, pumped by a 10 ns, 100 Hz, injection-seeded Q-switched Nd:YAG laser. Given the wide tunability of the NesCOPO, several absorption lines for CO₂ and CH₄ can be targeted (Fig.1.a)).

The single frequency radiation is amplified up to 16 mJ, using a PPLN preamplifier and KTA amplifiers. The emitter is then integrated in a DIAL system (Fig.1.b). The receiver unit is a home-build Newtonian telescope, coupled to a commercial amplified PIN photodiode. The maximum achievable detection bandwidth is 14.5 MHz, corresponding approximately to 10 m spatial range resolution cells along the line of sight.

3. TADI facility

Located in Lacq in France, TADI facility is an open-air site measuring 2,000 m² for qualifying systems designed to detect, localize and quantify remotely CO₂ and CH₄ releases. Equipped with surface facilities (pipelines, columns, recovered wellheads, etc.), this test area can reproduce around 30 scenarios of controlled emissions from 0.3 to 300 g/s of gas in an industrial environment.

3. GAZL testing on TADI facility

NAOMI GAZL was deployed on the TADI facility during a test campaign in October 2018. The DIAL was located 250 m away from the gas release system. Fig.2 a) and b) show an example of remote detection, quantification and localization of a CH₄ plume generated by TADI. The system was tested for different fluxes of CH₄ and CO₂. Comparisons with integrated concentration in ppm.m retrieved from LWIR imaging hyperspectral data acquired during this campaign can also be used then to analyse and validate GAZL results (Fig.2 c).

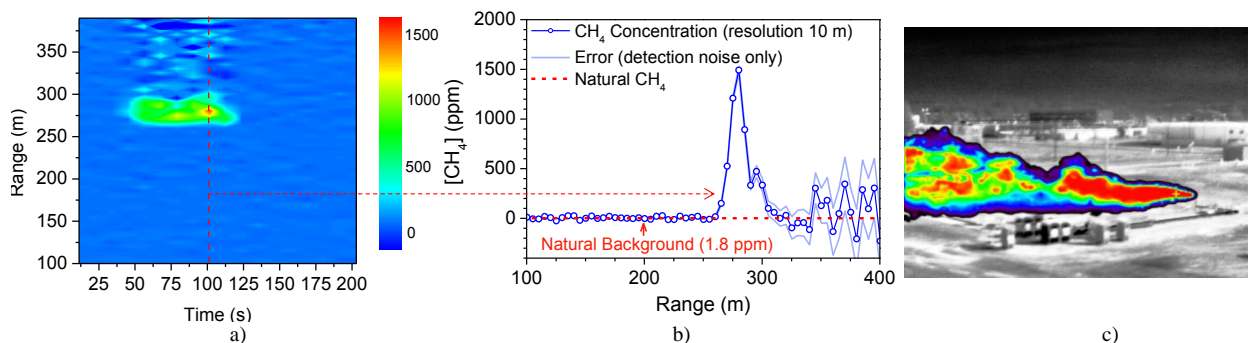


Fig. 2. a) Example of measurement performed using GAZL DIAL, on TADI facility : a gas plume is generated 250m away from the DIAL. The estimated CH₄ plume concentration with a 10 m range resolution and a 10 s temporal resolution is shown on the left curve. In b), we can see a zoom of the CH₄ concentration along the line of sight, with error bars corresponding to the detection noise. c) Methane plume quantitative image (range : 0-200.000 ppm.m) from hyperspectral LWIR data at a distance of 100m from the leak with a 5s temporal resolution and a 15cm spatial resolution.

Further details on the experimental set-up and obtained performances will be given and discussed.

4. Funding

This development was carried out in the frame of TOTAL and Onera NAOMI project.

5. References

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