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A-25

Characteristics of several NIR tuneable diode lasers for spectroscopic based gas sensing: a comparison

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Tuneable laser diodes were characterized and compared for use as tuneable sources in gas absorption spectroscopy. Specifically the characteristics of widely tuneable single frequency lasers, such as sampled grating distributed Bragg reflector (SG-DBR) laser and modulated grating Y-branch (MG-Y) laser diodes, recently developed for optical communications, with operating wavelengths in the $1520 \leq \lambda \leq 1570$ nm, are compared. The comparison also includes an external cavity laser (ECL) emitting at 935nm and a distributed feedback (DFB) laser. Characteristics investigated include, side mode suppression ratio, ease of tuning, tuning range, spectral emission linewidth, frequency stability, output power and wavelength modulation.

Widely tuneable diode lasers are capable of multi-species gas detection and are more complex than standard DFB lasers used for single-species gas sensing and have some undesirable artifacts in their operating behavior. However they present exciting opportunities for applications in absorption based multi-gas sensing regimes. Such wide wavelength tuning is not possible with conventional single frequency DFB devices whose use is typically limited to the detection of one gas.

B-25

Simultaneous detection of HCl and HF by TTFMS and high frequency WMS

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Laser-based systems have attained an increasing attention in recent years, due to their high sensitivity and selectivity. In particular, laser sensors based on the use of diode lasers emitting in the near- and mid-IR regions [1–2], represent a mature technology to achieve high sensitivity with a relatively cheap and small systems.

In this work, we present the development of a new compact sensor, based on the use of two different diode lasers, for continuous monitoring of chloridric and fluoridric acids. The purpose of the work is to perform in-situ measurements for diagnostic of exhaust gases coming from a waste inceneritor. In particular, HCl concentration is monitored by investigating the P(4) line at 1.7 μm in the ν_2 overtone vibrational band, while HF is detected observing the absorption of the R(3) line at 1.3 μm. These lines have a line-strength of $7.8 \cdot 10^{-21}$ cm/mol and $2.8 \cdot 10^{-20}$ cm/mol, respectively, and both are quite far from other lines which can introduce interference effects. As detection techniques we have used two different high frequency modulation techniques: for HCl detection we used Two-Tone Frequency Modulation Spectroscopy (f_1= 800 MHz and f_2=804 MHz) while for HF we followed a simpler approach based on Wavelength Modulation Spectroscopy (f=600 kHz). The two laser beams were overlapped and sent in a 30 m-long Herriott type multipass cell. All the optical elements are fixed on a breadboard (60x75 cm^2) and they have been properly designed to reduce as much as possible mechanical instability. The calibration of acid concentrations was performed by using known concentrations of water vapor lines close to the investigated HCl and HF lines. In spite of the differences in the two detection techniques, the sensitivities found for the detection of the two molecules were quite similar. Indeed the minimum detectable concentration at a total pressure of 100 Torr resulted to be 8 ppb and 18 ppb for HCl and HF, respectively. At atmospheric pressure these values were of the order of 0.2 ppm. Finally we tested the reproducibility of our measurements by repeating about twenty times the concentration measurements within several hours: from this analysis we estimated a precision around 10%.

References

[1] G. Pesce, G. Rusciano, A. Sasso: "Laser spectroscopy of OH fundamental vibrational band based on a difference frequency generator at 3 μm" , Chem. Phys. Lett. 374 425 (2003)

[2] G. Rusciano, G. Pesce, F. Pignatiello, A. Sasso: "A DFG-based spectrometer for high-sensitivity C_2H_2 and H_2O detection" Opt. Exp. 11 3010 (2003)

B-26

Stratospheric carbon monoxide in tropical convections: in-situ measurements with a mid-IR airborne spectrometer

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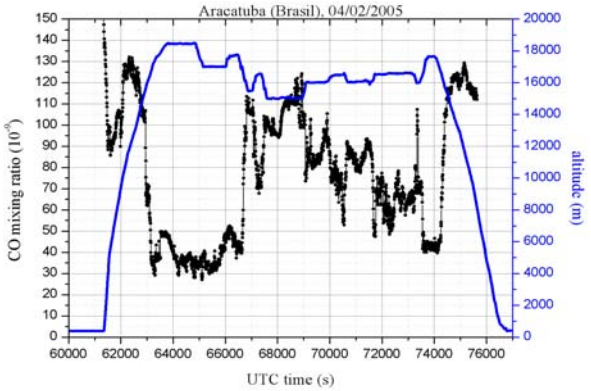
The contribution of tropical thunderstorms to the production of NOx is one of the main goals of the European Project TROCCINOX (TROpical Convection, Cirrus, and Nitrogen OXides Experiment) [1]. A set of airborne atmospheric research instruments (including LIDAR, Gaschromatograph and other chemical and meteorological sensors) provided *in-situ* atmospheric data during a 4 weeks airborne measurement campaign over Brazil. We present the results of our in-situ measurements of carbon monoxide concentrations in the upper troposphere/lower stratosphere during the TROCCINOX-2 field campaign in Araçatuba (Sao Paulo, BR) in January-February 2005. We have operated an airborne mid-infrared lead-salt diode-laser spectrometer [2,3], where the laser has been tuned to the strongest CO absorptions in the fundamental R branch centered at 2170 cm^{-1}. The instrument was carried on board of the russian stratospheric aircraft M55 Geophysica. A first data sample of the measurements is shown below.



Flight profile of CO concentration and corresponding altitude vs. time.

This activity has been sponsored by EC through contracts EVK2-CT-2001-00122 and EVR1-2001-00020, and by ESA in the frame of the ENVISAT validation programme.

References

[1] See: http://www.pa.op.dlr.de/troccinox

[2] G. Toci, P. Mazzinghi, and M.Vannini, *Journal of Atmospheric and Oceanic Technology*, **16**, 1295-1302 (1999).

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C-25

Development of a transportable spectrometer based on an erbium fiber doped laser for multiple trace gas sensing

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We present a novel spectrometer for real time and in situ trace gas sensing in near and mid-infrared. As optical pump source, an erbium doped fiber laser (EDFL) is used. This source generate near-IR continuously tunable from 1543 to 1602 nm with a power up to 1 W and a spectral linewidth less than 1 MHz. Furthermore this source will be employed to generate difference frequency with a second fiber laser (Ytterbium doped fiber laser) emitting near 1.06 µm. So this source would generate mid-IR from 2.8 to 3.3 µm with a power near 1 mW.

We present our preliminary results obtained in near-IR. Two detection schemes have been used :

1) Direct absorption in a Herriott multipass cell with 100 m optical path and a limited volume of 3.2 L ;
2) Cavity Ring-Down Spectroscopy (CDRS) with an equivalent optical path of ten kilometers.

Trace gas detection of acetylene (C_2H_2) and nitrogen protoxide (N_2O) with concentrations from some percents up to tens ppb have been achieved. Detection sensitivity is in the order of 10^{-7} cm^{-1} for direct absorption in the herriott cell and 10^{-10} cm^{-1} for CRDS.

Airborne measurement of CH_4 profiles during the TROCCINOX-2 campaign with the near infrared TDL instrument "ALTO"

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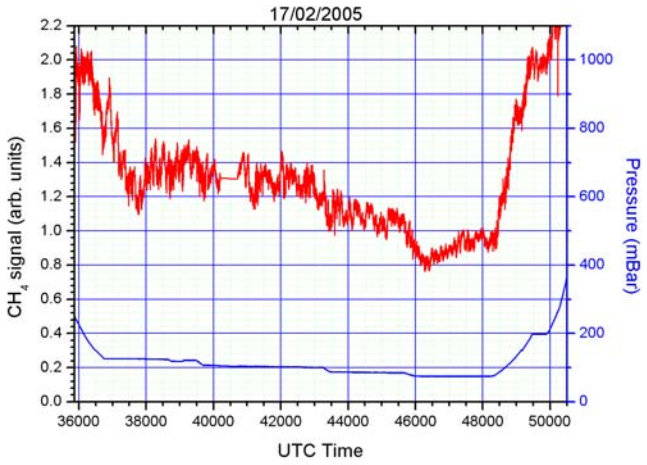
The contribution of tropical thunderstorms to the production of NOx is one of the main goals of the European Project TROCCINOX (TROpical Convection, Cirrus, and Nitrogen OXides Experiment) [1]. The TROCCINOX-2 field campaign started from the DLR in Oberpfaffenhofen (Germany) on Jan. 18, 2005 with the transfer flights of the russian M55 Geophysica and DLR´s Falcon to Araçatuba near Sao Paulo (Brazil). A set of airborne atmospheric research instruments (including LIDAR, Gaschromatograph and other chemical and meteorological sensors) provided *in-situ* atmospheric data during a 4 weeks airborne measurement campaign over Brazil. We have measured the CH_4 concentration during 15 flights with the near infrared spectrophotometer ALTO, which has been designed for unattended airborne operation [2,3]. A preliminary analysis of a methane flight profile is shown below. The flight profiles and the data quality will be discussed.



Typical recording of the CH_4 absorption signal strenght and outer pressure vs. time.

This activity has been sponsored by EC through contracts EVK2-CT-2001-00122 and EVR1-2001-00020, and by ESA in the frame of the ENVISAT validation programme.

References

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[2] F. D'Amato, P. Mazzinghi, and F. Castagnoli, *Appl. Phys*. **B75**, 195-202 (2002).

[3] M. Pantani, F. Castangnoli, F. D´Amato, M. De Rosa, P. Mazzinghi, P. W. Werle, Inf. Phys. & Technology **46**, 109-113 (2004).

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