BROAD-LINE PULSED POWERFUL LASER DIODES OF NIR BAND FOR COMPACT DIAL SCHEME

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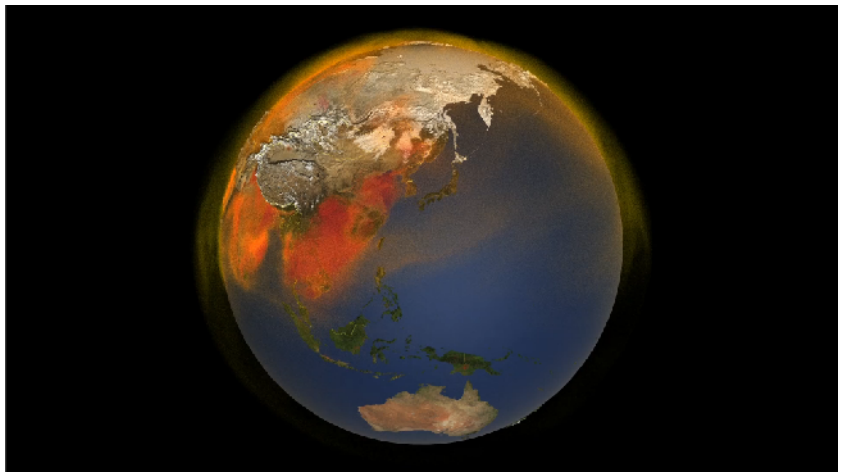
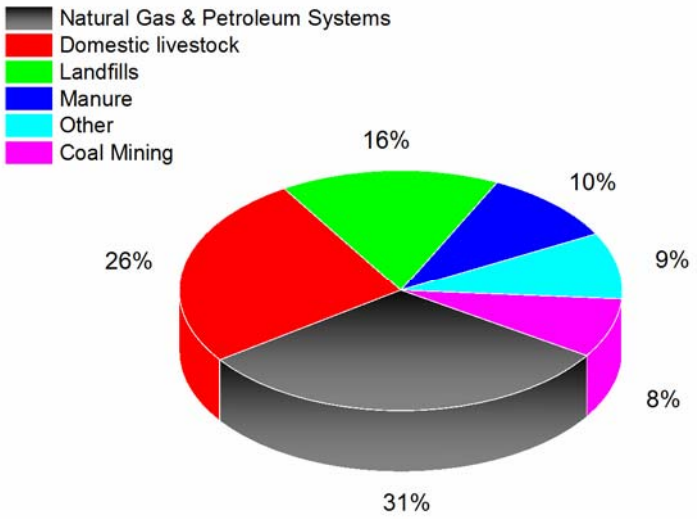
You must have adobe_flash_player installed to do so.

Why methane?

Courtesy of NASA





ADVANCED BROADBAND DIAL SOUNDER OF METHANE

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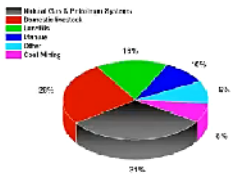
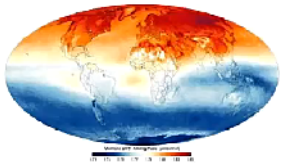
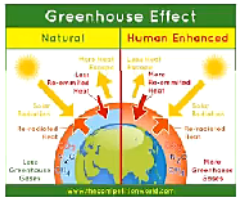
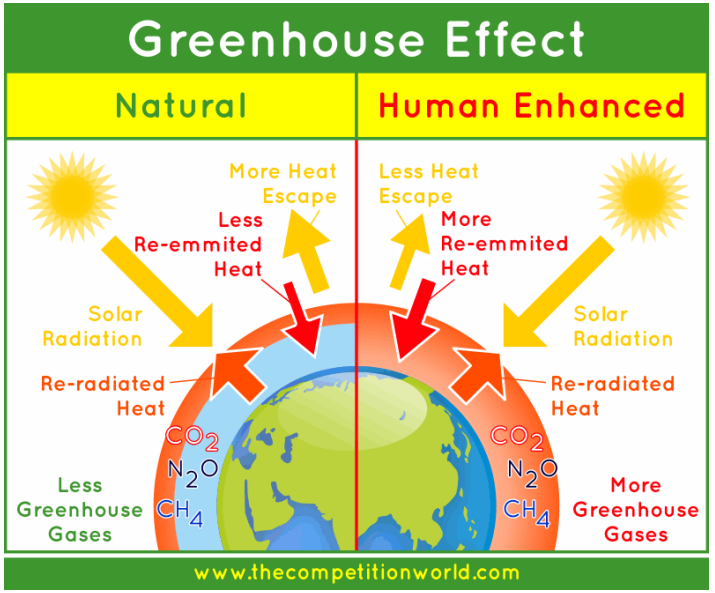






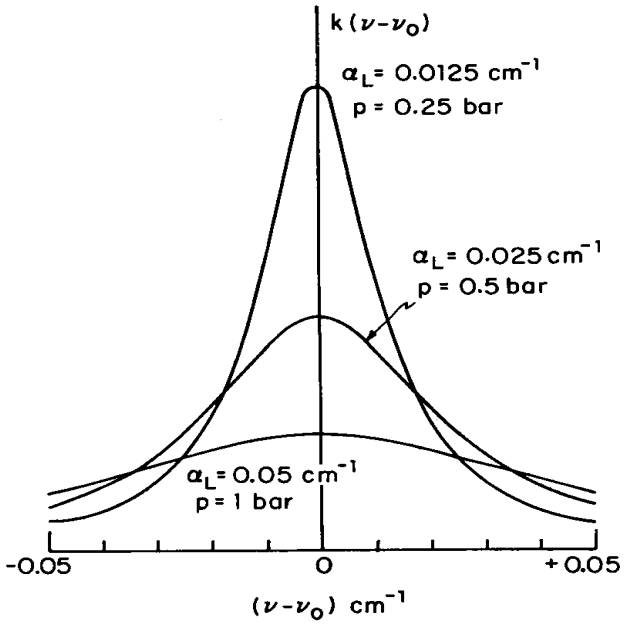


Broadband CH4 DIAL

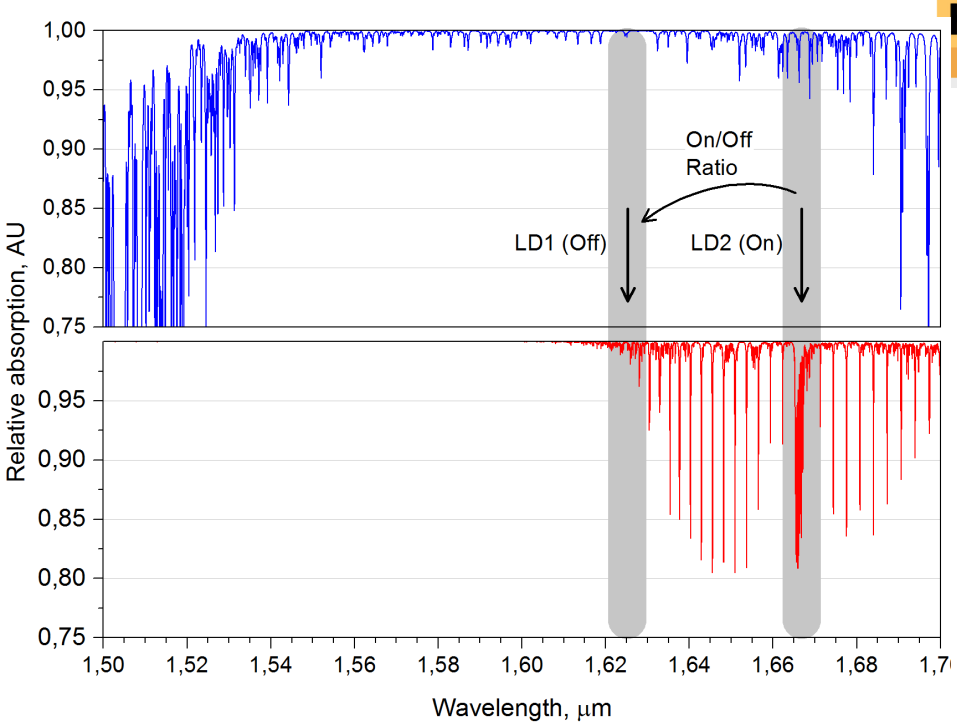
Infrared Atmospheric Sounding Interferometer (IASI)

Geophysical variables	Vertical resolution	Horizontal resolution
Humidity profile	1-2 Km (low Troposphere)	25 Km (cloud free)
CO, CH_4, N_2O	Integrated content	100 Km

A lidar sounder is advantageous for retrieval of range- resolved data of the atmospheric gas GMR. The conventional DIAL signal on dual wavelengths on/off an absorption line is replaced by the ratio of confined, integral absorption bands. The result depends on the absorption linestrength instead of the line amplitude subjected to pressure- broadening



Broadband CH4 DIAL on powerful LD



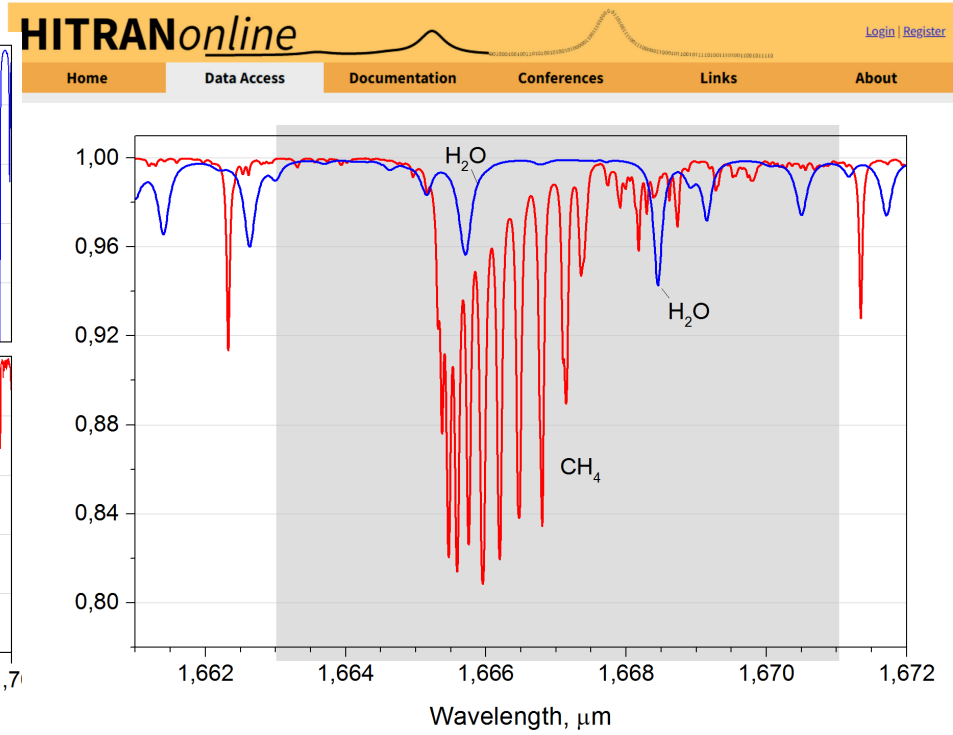


Fig.1 Differential absorption bands (vertical bars) of 8nm linewidth centered at 1.625μm and 1.667μm wavelengths matching CH_4 (red) and H_2O (blue) spectra

Fig.2 Scaled - up spectrum confined around 1.667μm wavelength

[1] Penchev S. et.al. (2012). Comptes rendus de l'Académie bulgare des Sciences, 65, 669-674.
[2] Thomas B. et.al. (2013), Applied Physics B, 113, 265– 75.

Multiplexation of DIAL signal

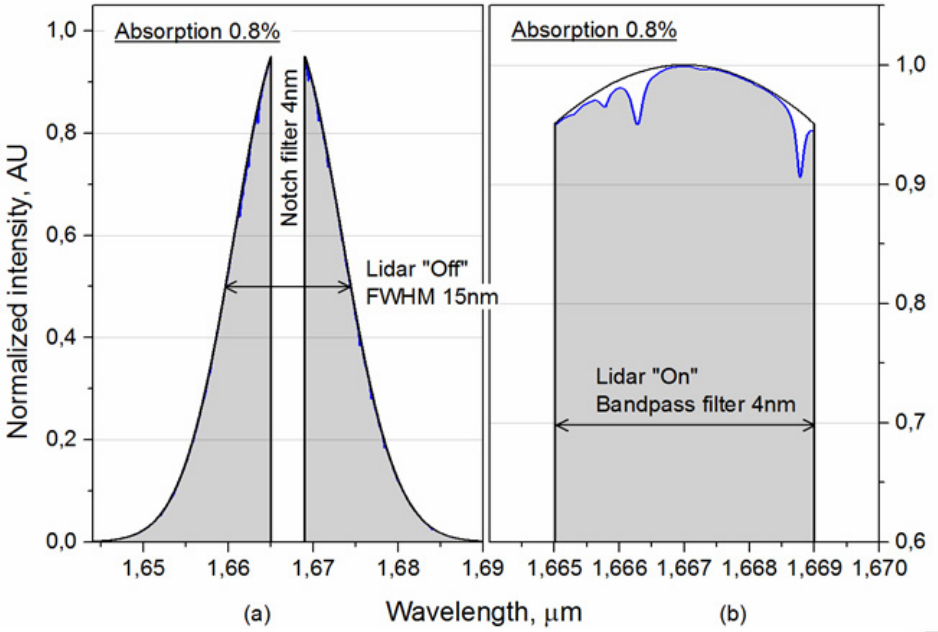


Fig.3 Multiplexed laser line of 1.667μm wavelength modulated by H_2O spectrum of 10gm^{-3} GMR on 1.5km lidar path: (a) "Off" band formed by a notch filter; (b) "On" band formed by a bandpass filter (scaled up along x-axis)

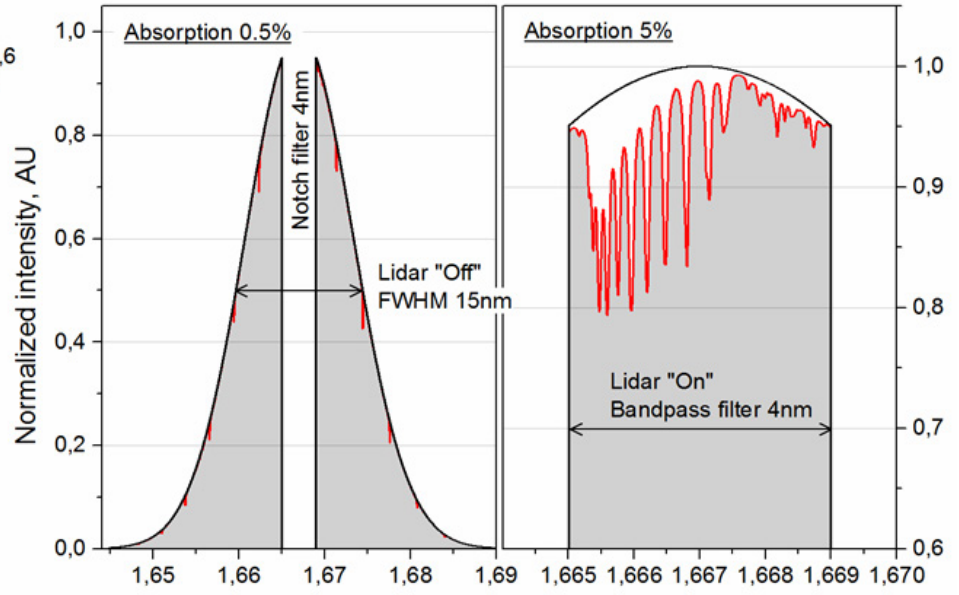


Fig.4 Multiplexed laser line as on the previous Figure 3 modulated by CH_4 spectrum of 10ppm GMR

[3] S.Penchev, V.Pencheva, T.Dreischuh, BG Utility model, Reg. № 4239, 2022.

Multiplexation of DIAL signal

Lidar returns of laser frequency ν_0 modulated by multiple absorption lines of frequencies ν_n are given by a convolution integral:

$$C = \int_{\nu} \exp\left[-4\ln 2 \left(\frac{\nu - \nu_0}{\Delta\nu_l} \right)^2 - K \sum_n S_n \frac{\Delta\nu_a^2/4}{(\nu - \nu_n)^2 + \Delta\nu_a^2/4} \right] d\nu$$

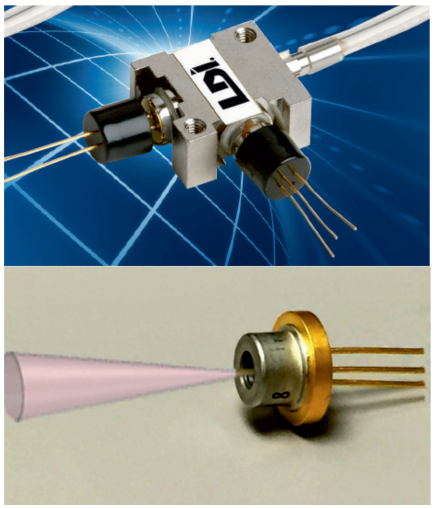
For weak absorption, the exponent is approximated by difference modulated by step- functions β and (1-β) with values of unity and zeros dscribing both spectral channels:

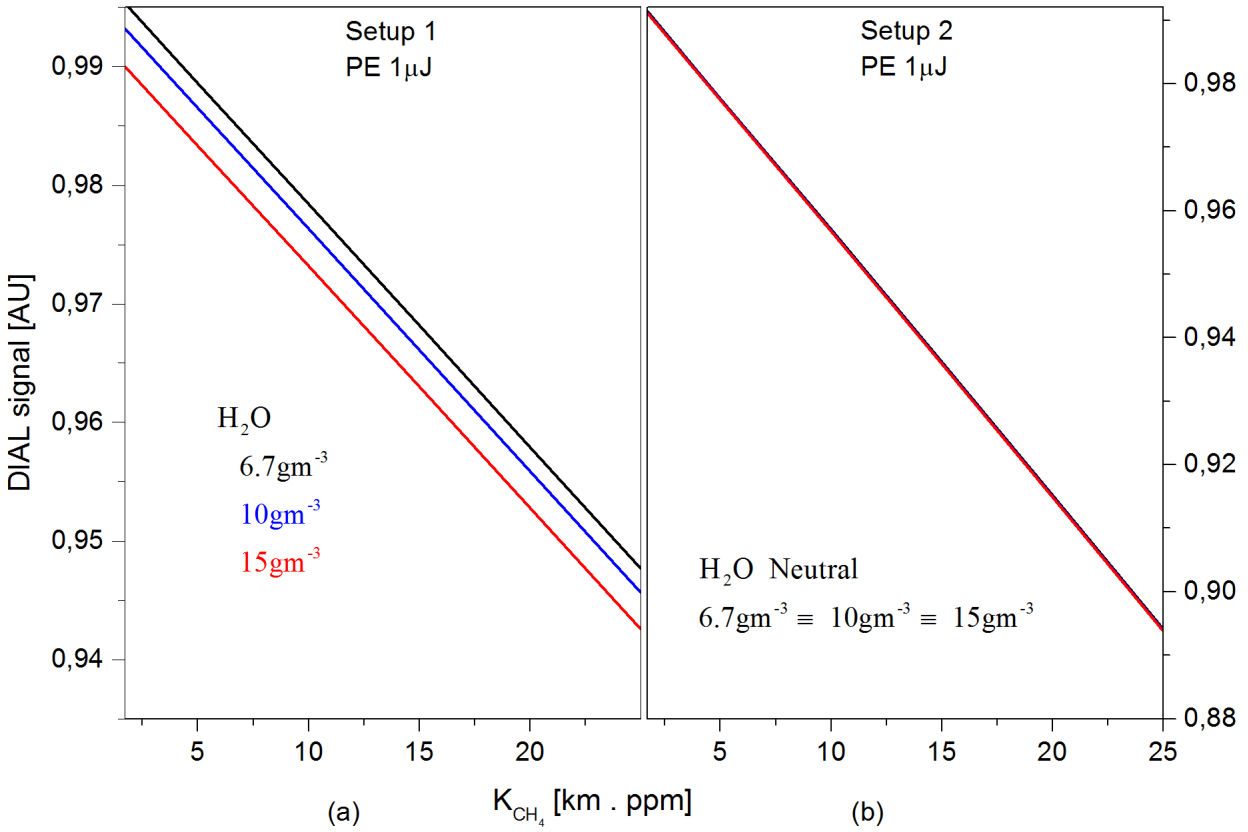
$$I_{DIAL} = C_{on} / C_{off} = \frac{\int_{\nu} \beta f_G \left(1 - K \sum_n f_L \right) d\nu}{\int_{\nu} (1-\beta) f_G d\nu}$$

Assuming equal intensities of absorption by water vapor in both spectral channels, results in an expression which depends solely on methane GMR:

- $$I_{DIAL} \approx 1 - \frac{\int_{\nu} \beta f_G \left(K \sum_n f_L \right)_{CH_4} d\nu}{\int_{\nu} \beta f_G d\nu}$$

Validation of absorption function





Absorption function for two LD types of 1μJ pulse energy vs. product K of CH_4 GMR and lidar path for different values of humidity:
(a) paired LD of 1.625μm- 1.667μm wavelengths and 8nm linewidth;
(b) multiplexed LD radiation of 1.667μm wavelength and 15nm linewidth

Prospective application

Beneath vast plains of Arctic tundra and swampy taiga forests lies permanently frozen ground, or permafrost. As northern polar regions continue to warm at a rate twice the global average, this permafrost begins to thaw. Unfrozen, waterlogged soils are like witches' cauldrons for methane, a greenhouse gas 25 times more potent than carbon dioxide.

- Diurnal monitoring of greenhouse gases affecting the global climate
- Mobile and airborne surveillance, particularly of inaccessible areas
- On demand safety controll of gas pipeline leaks
- Reconnaisance of energy resources

Q&A